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AND

THE ARTS.

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ARTICLE I.

Curious Circumstances upon which the Vitreous or the Stony Character of Whinstone and Lava respectively depend; with other Facts. In an Account of Experiments made by Sir JAMES HALL, *Bart. F.R. and A.S.S. Edin.**

ON the 5th March, and 18th of June, Sir James Hall read to the Royal Society of Edinburgh an account of a series of experiments on whinstone and lava. These experiments, which relate to the theory of the earth published by the late Dr. Hutton, had been projected by Sir James Hall in 1790; at which time he read a paper to the society on the formation of granite and other unstratified substances. He had then begun a few experiments, but had been obliged by some circumstances to discontinue them. Having obtained, however, very promising appearances of success, they were again resumed, and carried into effect in the course of last winter †. In the execution of the experimental part, Sir James Hall acknowledges himself greatly indebted to the assistance of Dr. Kennedy.

The subject of the communication was suggested by some obvious and plausible objections which have lately been urged against Dr. Hutton's system, Whinstone or basaltes being considered in that system as having attained its present position in a state of igneous fusion, it has been alledged, as a sufficient refutation of this hypothesis, that whinstone, when made to undergo fusion in one of our furnaces, yields glass, a substance very different from the original stone; the formation of which cannot therefore be ascribed to the action of fire.

* Abstract, by favour of the Author, from his Paper which will appear in the Edin. Transf. vol. v.

† Sir James Hall showed the result of his first successful experiment at a meeting of the Society on the 5th of February, 1798.

This difficulty had formerly occurred to Sir James Hall; who had endeavoured to obviate it by ftating, that the mafs during flow refrigeration in the bowels of the earth had undergone a change fimilar to that of glafs into Reaumur's porcelain; and that by cryftallization it had loft the vitreous, and affumed the ftony character. The truth of this explanation has now been amply confirmed by thefe experiments, which comprehend feven different fpecies of whinftone. Each of the original fubftances was reduced, by fufion and fubfequent rapid cooling, to a ftate of perfect glafs. This glafs, being again placed in the furnace, was fubjected to a fecond fufion. The heat, being then reduced to a temperature generally about 28° of Wedgwood, was maintained ftationary for fome hours; when the crucible was either immediately removed, or allowed to cool with the furnace. The confequence was, that in every cafe the fubftance had loft the character of glafs, and by cryftallization had affumed in all refpects that of an original whinftone.

It muft be owned, that in moft cafes the new production did not exactly refemble the particular original from which it was formed, but fome other original of the fame clafs; owing to accidental varieties in the mode of refrigeration, and to chemical changes which unavoidably took place during the procefs. In the cafe, however, of the rock of Edinburgh Caftle, and of that of the bafaltic columns of Staffa, the artificial fubftances bear a complete refemblance to their originals, both in colour and texture.

Sir James Hall conceives, that the objection to Dr. Hutton's fyftem, mentioned above, is thus completely obviated; fince the ftony character of whinftone is fhown to be the natural confequence of the flow refrigeration, which, according to that fyftem, muft have taken place in the bowels of the earth, as the fubftance of whinftone paffed from a liquid to a folid ftate.

Experiments were made with equal fuccefs on lava. This clafs of bodies is known to poffefs the cryftalline and ftony character, in common with whinftone, and to refemble it fo much, that in many cafes the two fubftances cannot be diftinguifhed by their external appearance *. In others, however, certain circumftances occur by which they are characterized. But in confequence of fufion thefe diftinguifhing marks difappear; and the glafs of a lava feems in no refpect to differ from that of a whin. Sir James Hall therefore infers that the two fubftances are intrinfically the fame, and afcribes their differences to the circumftances under which each clafs paffed from a liquid to a folid ftate; the lavas having cooled in the open air, and the whins, according to Dr. Hutton, in the bowels of the earth. Six lavas, four of which † made part of undoubted currents of Ætna and Vefuvius, and broken from thofe currents by Sir James himfelf, were fubmitted to experiment. The glafs produced by fufion and rapid cooling, yielded, when treated like the glafs of whin, the fame kind of cryftallized, ftony, or earthy maffes, completely refembling an original whin or lava.

In the courfe of thefe experiments, the fufibilities of the various original fubftances, and of thofe artificially produced, were afcertained with much care by Wedgwood's pyrometer,

* Thefe obfervations are applicable to lavas in general, comprehending all thofe of Ætna and Vefuvius; but do not ftrictly apply to fome of the lavas of the Lipari Ifles, and of Ifchia, which poffefs fome curious and interefting properties to be mentioned in a future communication. H.

† No. 8, 9, 11 and 12 of the table.

and

Apparatus for bleaching.

Fig. 1.

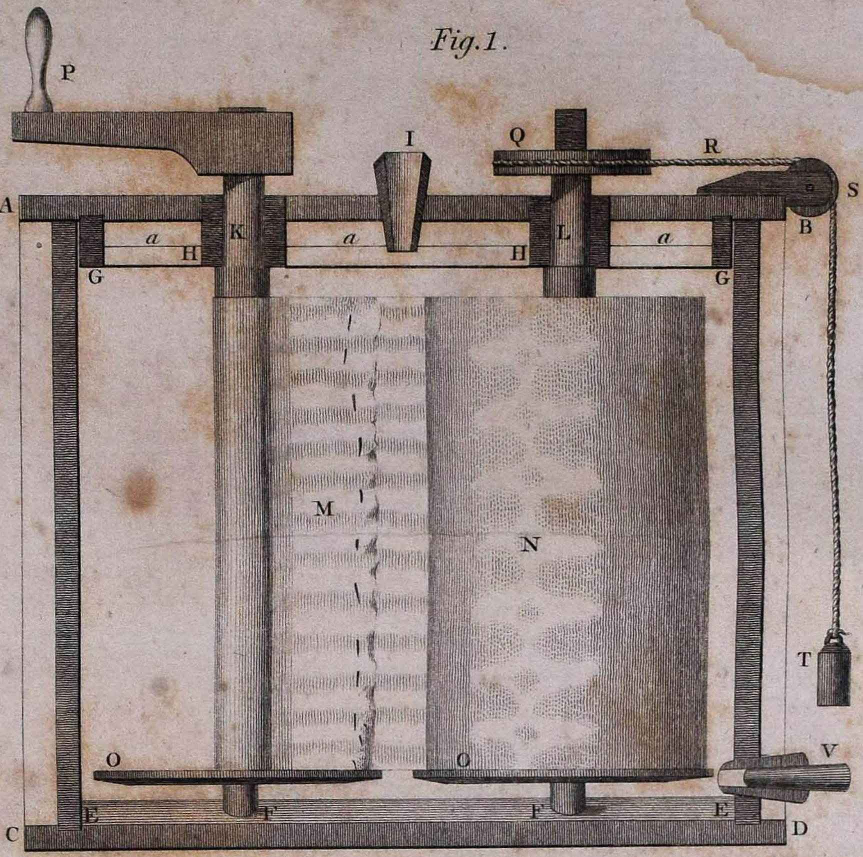
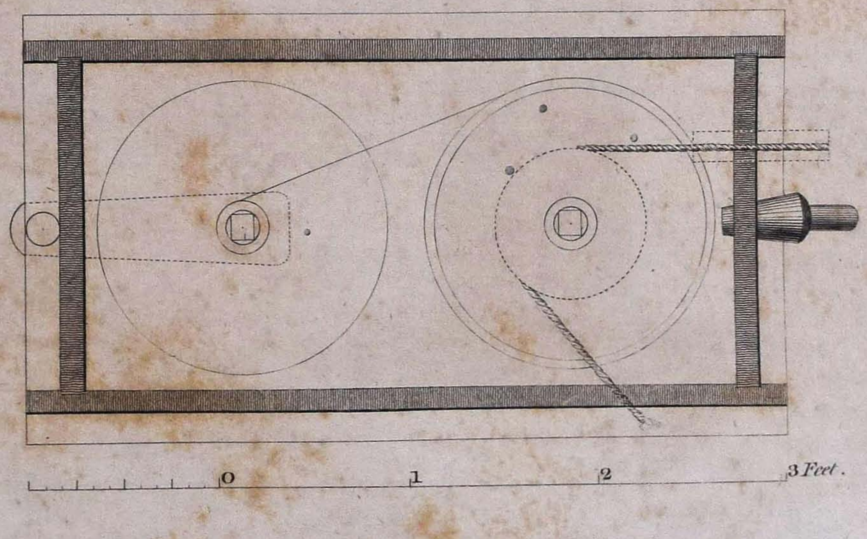
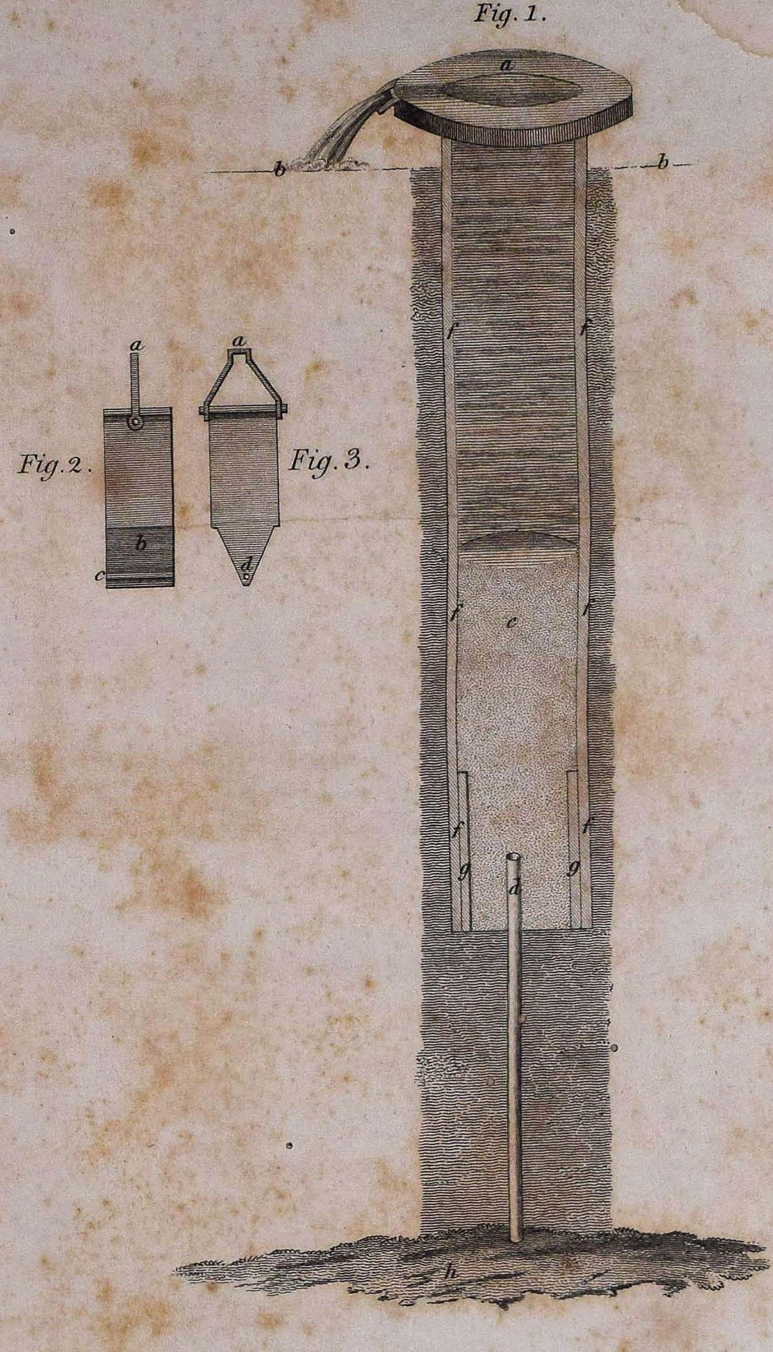


Fig. 2.



Barlow sculp.

An Artificial overflowing Well



Barlow sculp.

and are ſtated in the annexed table, which may be depended upon, in every example, to within two, or at moſt three degrees. The artificially cryſtallized ſubſtances have been denoted, at Dr. Hope's ſuggeſtion, by the name of *cryſtallite*.

The various fuſibilities ſtated in the table afford ſome concluſions of conſequence. The whins ſubmitted to trial are more refractory than the lavas; though their exceſs in this reſpect is not great, ſince the moſt fuſible of the former claſs equal the moſt refractory of the latter. The glaſſes are all incomparably more fuſible than the original ſtones. This laſt circumſtance has long been known as a fact; but Sir James propoſes to ſuggeſt the theory of it, and of all the peculiarities which occurred in thoſe experiments, in a ſecond communication which he means ſoon to lay before the Society.

It is obſervable, that the lava No. 12 is fuſible at 18; that is, it reſembles in this property the moſt fuſible glaſſes. And it is in fact a glaſs; for, being lifted in a ſoft ſtate from a flowing lava of Veſuvius by Sir James Hall, it quickly cooled, and has of conſequence aſſumed the vitreous character in every reſpect: for, beſides its eaſy fuſibility, it poſſeſſes the ſhining ſurface and fracture of glaſs. This ſubſtance, being treated like the artificial glaſſes of whin and lava, cryſtallized like theſe, and aſſumed the character of a ſtony lava, both in texture and in difficult fuſibility, ſince it ſoftened only at 35°. Here then is a proof beyond diſpute, that the ſtony character of a lava is occaſioned ſolely by ſlow cooling.

Although the internal ſtructure of lava was thus accounted for, yet Sir James was embarraſſed with the ſtate of its external ſurface; which, though cooled in contact with the open air, is ſeldom or ever vitreous, holding an intermediate ſtation between glaſs and ſtone;—but this difficulty was removed by a circumſtance which took place in the courſe of theſe experiments. It was found that a ſmall piece of glaſs of any of the lavas, or of ſeveral of the whins, being introduced into a muffle, the temperature of which was at any point between the 20th and the 22d degree of Wedgwood's ſcale, the glaſs became quite ſoft in the ſpace of one minute; but, being allowed to remain till the end of a ſecond minute, it was found to have become hard throughout in conſequence of a rapid cryſtallization, to have loſt its character of glaſs, and to have become by 12 or 14 degrees more infuſible, being unaffected by any heat under 30, though the glaſs had been fuſible at 18° or at 16. This accounted for the ſcoria on the ſurface of lavas; for the ſubſtance even at the ſurface, being in contact with the flowing ſtream and ſurrounded with heated air, could not cool with exceſſive rapidity; and the experiment ſhows, that ſhould any part of the maſs, in deſcending heat, employ more than one or two minutes in cooling from 22 to 20, it would infallibly loſe its vitreous character.

The internal phænomena of volcanos being thus explained by the properties of common fire, and the reſemblance, or identity, of many lavas and of whinſtone being thus eſtabliſhed, Sir James Hall conceives, that the powerful arguments advanced by Dr. Hutton, to prove the igneous origin of whinſtone and other mineral bodies, are very ſtrongly corroborated; ſince theſe experiments ſhow that theſe ſubſtances may have been formed by a ſimple extenſion of the ſame cauſes which continue at this day to agitate various parts of our globe.

Independently however of any alluſion to ſyſtem or to general theory, Sir James Hall flatters himſelf that theſe experiments may be of ſome importance by ſimplifying the hiſtory of volcanos; and above all by ſuperſeding ſome very extraordinary, and, he conceives,

 unphiloſophical

unphilosophical opinions advanced with regard to volcanic heat, which has been stated as possessing very little intensity, and as acting by some occult and inconceivable influence, or with the help of some invisible agent, so as to produce liquidity without fusion. These suppositions, which have been maintained seriously by some of the most celebrated naturalists in Europe, have originated from the difficulty of accounting for the stony character of lavas, when compared with that of glass, which they assume in consequence of fusion in our furnaces. But now he hopes we may be relieved from the necessity of such violent efforts of imagination, since the phænomena have been fully accounted for by the simple though unnoticed principle of refrigeration, and have been repeated again and again with ease and certainty in a small chamber furnace.

TABLE.

The fusibilities, according to Wedgwood's pyrometer, stated in the following table, were ascertained by heating the substances in a muffle, in which they could be distinctly observed, while exposed to the action of the heat. A small piece of the substance to be examined being put into the muffle, a pyrometer-piece was placed close beside it, and the heat raised gradually. The substance was touched at intervals with a slender iron rod; and when found so soft as to yield easily to slight pressure, the pyrometer was withdrawn, and measured.

[All the whins except No. 7. were taken from their original rocks in the neighbourhood of Edinburgh.]

		Original substances softened.	Glass softened.	Crystallite softened.
No. 1.	Whin from a quarry on the Water of Leith,	40;45	17;15	33
No. 2.	Whin of the rock of Edinburgh Castle,	45	24;22	35
No. 3.	Whin of basaltic columns—Hill of Arthur's Seat,	55	18	35
No. 4.	Whin from the south side of Arthur's Seat, near Duddystone,	43	24	38
No. 5.	Stone of the nature of whin, found in large blocks in the bed of Water of Leith,	55	16	37
No. 6.	Whin of Salisbury Rock,	55	24	38;40
No. 7.	Whin of basaltic columns, Staffa,	38	—	—
No. 8.	Lava of Ætna, which destroyed part of Catania in 1669,	34	20	38
No. 9.	Lava near Piedmonte—Ætna,	32	18	36
No. 10.	Lava of La Motta di Catania—Ætna,	38;42	18	36
No. 11.	Lava of Torre del Greco—Vesuvius,	40	18	27;28
No. 12.	Lava lifted red hot from a flowing stream on Vesuvius, by Sir James Hall,	18	18	35
No. 13.	Lava from Iceland,	35	15	43

II.

On the Analysis of Pumice, which is found to contain Potash; and of Basaltes and Lava containing Soda. By Dr. KENNEDY *.

ON the 5th of February 1798, an analysis of pumice was communicated to the Royal Society of Edinburgh by Dr. Kennedy. By this analysis he shewed that the pumice contained potash as one of its component parts. The specimen analysed was of the common kind, having a fibrous texture and a silky lustre. By a heat of 60° of Wedgwood, it was converted into a kind of glassy enamel; and in a muffle, even at a heat of 35 or 40, was so far altered, that its fibrous texture could no longer be distinguished. Besides potash, it contained silex, argill, and a small quantity of iron; but no lime or magnesia.

Several other varieties of the common kinds of pumice used in the arts, were found as fusible as the specimen above mentioned, and gave the same kind of glassy enamel.

The result of the analysis, with respect to the earths and iron, corresponds very nearly with the result of Mr. Klaproth's, published in the 2d vol. of his Beiträge; only he did not find potash in the specimen he analysed; in which, however, there was probably some saline substance; for the same kind of pumice melted in the porcelain furnace of Berlin; in which a compound consisting only of silex, argill, and a minute portion of iron, would certainly not have melted. The heat of this furnace was 136 of Wedgwood.—See Klap. Beytr. vol. 2d, p. 88.

On the 6th of August Dr. Kennedy announced to the Society, that he had discovered mineral alkali in several varieties of basaltes or whinstone. He found by chemical analysis, that the alkali existed in these substances in a state of very intimate combination with their earthy bases; and that it was with difficulty separated, even by the strongest acids.

Dr. Kennedy also analysed a specimen of lava from Ætna, at the request of Sir James Hall, who thought it extremely probable that alkali would be found in lava, as well as in basaltes, on account of the great resemblance which these two substances have to each other, both in external appearance and in many chemical properties. The specimen was broken, by Sir James Hall and Dr. Hume, from the celebrated current of lava which in 1669 destroyed part of the town of Catania. It was found, like the basaltes, to contain soda.

One of the fixed alkalis, potash, has already been discovered in stony substances by the celebrated Mr. Klaproth, to whom the world is indebted for so many analyses performed with the greatest skill. The experiments above-mentioned show, that the other fixed alkali, soda, likewise exists in stony substances.

* Abstract, by favour of the Author. This paper will appear in the 5th vol. of the Edinburgh Transactions.

III. *Experiments*

III.

Experiments and Observations on the Preparation, and some remarkable Properties of the Oxygenated Muriat of Pot-ash. By Mr. THOMAS HOYLE, *jun.* *

HAVING an opportunity in preparing the oxygenated muriatic acid for the purpose of bleaching, by a small extension of the apparatus, to prepare likewise the oxygenated muriat of potash, and to make experiments on that substance, I have been induced to digest the most material facts and observations which occurred, and to lay them before the Society: especially as I do not find much on the subject in the writings of others, and as many have probably been deterred from the investigation by the exorbitant price of the article, and by some apprehensions of danger attending it.

A few experiments, which are not new, have been introduced, in order to bring under one point of view the principal chemical facts which relate to this salt. I have given in most cases an exact account of the quantities of the different ingredients composing the mixtures; and as persons not much accustomed to such experiments may be inclined to repeat some of them, I would caution them *not to use greater quantities than are here specified*, particularly where the terms violent detonation, explosion, &c. are employed.

I would not by any means wish it to be understood that I have exhausted the subject: many more experiments and much labour and assiduity are required, before the nature and uses of so active a substance can be fully ascertained.

I find it has been introduced into medicine with success; and I hope its good effects in that respect will not be frustrated by the high price of the article, as it may be procured at a much cheaper rate than it is commonly charged.

I. *On the Preparation of the Salt, and its Solution in Water and the Acids.*

Finding that a quantity of gas escaped occasionally from our apparatus for making the new bleaching liquor, more especially when the fire was not properly managed, or when, by any other means a greater quantity of gas was produced than the liquor could absorb; I thought it would be useful to adapt to the large apparatus a smaller one, in which this superfluous gas might be condensed; as the escape of it was sometimes disagreeable to the workmen. This I did by filling an earthen-ware bottle with a strong solution of potash in water (consisting of about three pounds of alkali to the gallon), which I found entirely relieved us from the disagreeable smell we frequently experienced before, and at the same time yielded a considerable quantity of the oxygenated muriat. Though the production of the oxygenated muriat in this way be somewhat precarious, depending upon the management of the person who conducts the process (it being the bleacher's interest to condense the whole of the gas in the liquor he wants for his business); yet I think, if the portion which commonly escapes were thus disposed of, a considerable quantity of this salt might be made by bleachers with little additional expence, except what is incurred by the purchase of the alkali, and some more labour and attention. At some of my first trials, about two years ago, I found the gas which escaped from the materials of one distillation sufficient to saturate two gallons of the alkaline solution, from which I procured about six ounces, and

* Manchester Memoirs, vol. v. part i.

sometimes

ſometimes more of the ſalt, after being purified by ſeveral cryſtallizations. But having made ſome alteration in the apparatus, I now find that the ſame quantity of alkali may remain for three or four diſtillations before ſufficient gas be furniſhed to form the ſalt; except the perſon employed be remarkably inattentive to his duty. I conſider this as a valuable improvement, the making of the ſalt being only a ſecondary object. The ſalt was chiefly formed during the diſtillation. The alkali became warm toward the latter end of the proceſs, eſpecially if the abſorption of gas was very rapid, a quantity of caloric being diſengaged. In this caſe, a conſiderable part of the ſalt ſoon cryſtallized, on the lixivium being ſet in a cool place, and a great deal of gas appeared to eſcape; which on one occaſion I collected, and found that it precipitated lime from its ſolution in water, and extinguiſhed flame: and therefore, though it had a ſlight ſmell of the oxygenated muriatic acid gas, I believe that it conſiſted chiefly of carbonic acid, as the former occaſions no precipitation of lime water, which the latter uniformly does. A glaſs jar containing 32 ounce meaſures of this gas, being left over water one night, was reduced to about one fourth its bulk. The gas that remained ſeemed to contain more oxygene than the air of the room; two meaſures of it, with one of nitrous gas, gave 1.53, whilſt an equal quantity of common air gave 1.9.

Before any of the ſalt appeared to be formed in the alkaline ſolution, I have conſtantly obſerved a quantity of earthy matter to be precipitated. This was carefully ſeparated from the ſalt, and, after being waſhed repeatedly in boiling water, was ſuffered to dry; but not having examined it with ſufficient minuteneſs to ſay what it is, I ſhall content myſelf at preſent with ſtating ſome of its properties. It did not detonate with ſulphur, and was totally or nearly inſoluble in water. The ſulphuric acid diſſolved it, and gave evident ſigns of muriatic acid, which appeared to be ſlightly oxygenated. After being expoſed to a red heat for half an hour, the above properties ſtill appeared the ſame, except with the ſulphuric acid. I thought the gas that was diſengaged had more of the ſmell of ſimple muriatic acid gas, though along with it a little of the oxygenated gas might be perceived. The muriatic acid did not appear to diſſolve any of this ſubſtance, either before or after its calcination. With the nitrous acid a ſtrong ſmell of the oxygenated muriatic gas was produced. From a dram of this ſubſtance in an earthen retort expoſed to a ſtrong heat, about ſix ounce-meaſures of gas were produced, conſiſting of a mixture of carbonic and azotic gas, the latter of which was in the greateſt quantity, forming by eſtimate about three fourths of the whole.

The form of the cryſtals that firſt appeared in the ſolution of alkali were quadrangular plates: what were afterwards formed, when the lixivium became cool, were needle-like, as were thoſe that were produced by ſpontaneouſly evaporating the remainder of the ley: they appear to have the ſame property of detonating as the firſt. Theſe different forms of cryſtals appeared on diſſolving the ſalt in hot water, and, when cold, ſeparating the ſalt, and ſuffering the water to evaporate ſpontaneouſly.

I frequently obſerved, that unleſs the alkali began to part with a conſiderable portion of gas without the admiſſion of any from the apparatus, little or none of the oxygenated muriat was procured; and that as this gas (which I have before obſerved to be chiefly the carbonic acid) eſcaped, the cryſtallization took place, and increaſed or diminiſhed according to the evolution of that gas. This I found uniformly the caſe, whether mild or cauſtic alkali

alkali was employed. A given quantity of the ſtrong ſolution of potaſh appeared to produce more of this ſalt than the ſame quantity of a ſolution of pearlaſh of the ſame ſpecific gravity.

The remaining lixivium, on evaporation, did not yield this ſalt, though a muriat of potaſh was formed, that appeared to be conſiderably oxygenated: ſince, with the addition of the ſulphuric or muriatic acid, it became a very powerful deſtroyer of vegetable colours; it would not detonate with ſulphur, or inflame combuſtible ſubſtances, with acids; it was very ſoluble in water, much more ſo than the muriat firſt formed from the ſame alkali.

I may here remark, that I think the French chemiſts were right in calling the firſt ſalt the hyperoxygenated muriat, as the ſalt laſt mentioned is certainly oxygenated in ſome degree: however, in the following experiments I ſhall uſe the term oxygenated muriat, when ſpeaking of the ſalt formed during the diſtillation, and on cooling the lixivium after being ſaturated with the gas.

Experiment I. One part of the oxygenated muriat of potaſh required about ſeventeen parts of water at the temperature of 60°, to diſſolve it; whilſt five parts of boiling water diſſolved two of the ſalt. Repeated ſolutions did not appear to injure, but rather to increaſe, its detonating property. The cryſtals became much whiter; and a quantity of the earthy matter before mentioned was ſeparated at every freſh cryſtallization.

Experiment II. A quantity of this ſalt was put into a bottle, and placed in a ſituation much expoſed to the light: after being kept there more than twelve months, it did not appear to have loſt any part of its detonating property. This fact is contrary to Chaptal's aſſertion, that the mere impreſſion of light is ſufficient to decompoſe it *.

Experiment III. Water ſaturated with this ſalt was expoſed to the light for ſeveral months, without appearing to be at all changed. It was put into a bottle with a ground ſtopper and tube, to which an apparatus was adapted to receive any gas that might come over; but no gas whatever was diſengaged.

Experiment IV. Sixty grains of ſalt were fuſed by the heat of a lamp in a bottle with a ground ſtopper and tube. After having been kept in a fluid ſtate for about half an hour, I found that it had loſt two grains in weight, and that a ſmall quantity of air was given out, which proved to be oxygenous by the teſt of nitrous gas. The ſalt which had been melted would ſtill detonate with ſulphur, &c. The loſs of weight was, I am inclined to think, chiefly owing to the eſcape of the water of cryſtallization; for the ſalt when cool had loſt its tranſparency.

Experiment V. From forty grains of the ſalt in an earthen retort, I procured by the application of heat about thirty-ſix cubic inches of oxygenous gas; the evolution of which was very rapid, and commenced as ſoon as the retort became ſlightly red. Forty grains expoſed in a crucible to a ſtrong red heat appeared, from the mean of two experiments, to have loſt about ſeventeen grains in weight. The remaining muriat, being afterwards thrown into the ſulphuric acid, produced a very ſtrong ſmell of oxygenated muriatic acid; from which I inferred that the whole of the oxygen had not been expelled by the heat; whence the oxygenated muriat of potaſh may, I think, be ſtated to contain about half its weight of oxygen in a concrete ſtate.

* Elements of Chemiſtry, i. 250.

Experiment

Experiment VI. Strong nitrous acid disengaged the oxygenated muriatic acid from this salt. During the solution of two or three grains of the oxygenated muriat in this acid, a grain or two of phosphorus was dropped into the glass containing the mixture; when a number of vivid flashes appeared in the liquor, darting forth at intervals for a considerable time. This is one of the most striking experiments I ever saw; but a little caution is necessary in performing it, the phosphorus being sometimes thrown out of the mixture *.

Experiment VII. The muriatic acid dissolved this salt, a great deal of the oxygenated acid being given out. A few grains of the salt added to an ounce of the acid rendered it a very powerful destroyer of vegetable colours. This mixture may probably be used with advantage in taking stains of ink, &c. out of linen or cotton.

Phosphorus added to this acid along with the salt did not produce the same effect as with the nitrous acid; no light appearing, as in the last experiment.

Experiment VIII. On putting a little of the salt into the sulphuric acid, a violent crackling, or a great number of small explosions, took place, and a very strong smell of nitrous gas was produced; the mixture at the same time assuming an orange colour, which disappeared after it had stood a short time. A very small piece of phosphorus having been dropped on about two grains of the salt (previously thrown into the acid), an explosion immediately took place, which blew out a great part of the mixture upon my hand; an accident that might have proved serious if I had not had water near me.

Experiment IX. Finding a great quantity of gas to be disengaged from this salt by the sulphuric acid, which had a very strong smell of nitrous gas, I put forty grains of the salt into a glass retort, and poured upon it nearly an equal weight of sulphuric acid diluted with water. With the heat of a lamp the gas began to come over very rapidly, and was received in a glass jar placed in a bason of water. A considerable portion of it appeared to be absorbed by the water, which acquired a yellowish colour. This colour disappeared on standing a few days, and a brown matter was deposited, which being carefully collected and dried weighed one grain, and appeared to be manganese; for a little of it, being put into the muriatic acid, so far oxygenated it that it would destroy the blue colour of a diluted solution of indigo in the sulphuric acid. The precipitate before mentioned, that was first produced in the alkali employed, did not appear to have this effect. The quantity of this sediment that I had an opportunity of collecting was so small, that I could not try many other experiments with it: indeed I did not always succeed in procuring it; for I found that, unless the disengagement of the gas was very rapid, but little of it could be obtained.

Experiment X. On two drams of the salt in a glass retort, I poured an equal weight of sulphuric acid diluted with a little water, and adapted the retort to Woulfe's apparatus. The heat of a lamp was applied; and presently the gas began to escape, and was absorbed by the water in a considerable quantity; to which it communicated a yellowish colour, and a liquid began to trickle down the neck of the retort into the receiver. This had continued but a short time before a violent explosion took place, which broke the retort and two of the receivers to pieces, together with several other glasses which were on the table. This was several times repeated, but with more caution than before; and I always found,

* This curious experiment was first noticed by J. Collier, and was communicated by him to the Society some time ago.

that when the mixture acquired a certain degree of heat an explosion certainly took place, except the retort had a pretty wide neck, and the neck was simply introduced into a receiver with a considerable opening in it without any lute; or put into water, as in the last experiment: and even in this case I would not advise so much of the salt to be used at one time as is here mentioned. The small quantity of acid I was able to collect in this way, by adapting a loose receiver, appeared to be a weak muriatic acid slightly oxygenated; it was of a dilute purple colour, which disappeared on its being exposed a short time to the light: a small piece of iron dropped into it caused it to become transparent immediately.

It was a matter of much surprise to me, to find so strong a smell of nitrous gas produced on decomposing this salt with sulphuric acid. Now, as nitrous gas consists of azot and oxygen, supposing this to be nitrous gas (for I do not assert it to be so, though I should think the smell in this instance an almost sufficient criterion), whence comes the azot? At first I thought it might come from a decomposition of the alkaline base of the salt; as some chemists have imagined the vegetable alkali to be composed of lime and azot: in that case, I expected the residuum would have been the sulphat of lime; but I found it to be chiefly sulphat of potash, with a little of the oxygenated muriat that remained undecomposed along with it. At present I shall not hazard any opinion respecting the origin of this nitrous smell; but hope some experiments I am at present engaged with will, if I can find time to prosecute them, throw some light upon this subject.

II. *On the Detonation and Inflammation of combustible Substances with the Salt produced by Friction and the Acids.*

THE detonating properties of this salt were tried with various substances in the following experiments: the different mixtures were intimately combined by gently rubbing them in a stone-ware mortar: after this was done, one smart stroke across the mixtures would cause the whole of some of them to explode at once, and others successively by repeating the friction. The sulphuric acid inflamed most of these mixtures of the salt with combustible substances: the nitrous acid also had the same effect with some of them.

Experiment I. *with Phosphorus.* Half a grain of this substance rubbed with the same weight of the salt produced violent explosion with flame. I apprehended it would be dangerous to use much greater quantities, as the phosphorus is frequently thrown out with violence before it is consumed. The sulphuric acid inflamed this mixture, as I have before stated.

Experiment II. *with Charcoal.* Two grains of salt with one of charcoal intimately mixed, and perfectly dry, produced by a smart stroke a strong flame without much report. The sulphuric and nitrous acids inflamed this mixture, the latter with most rapidity.

Experiment III. *with Pit-coal.* A grain of dry pit-coal rubbed with the same quantity of the salt produced sparks and some small reports. With half the quantity of coal the reports were much louder.

The sulphuric acid added to about twenty grains of the salt with ten of the coal, produced a bright red flame rising up to a considerable height.

Experiment IV. *with Sulphur.* A grain of the salt rubbed with half a grain of sulphur produced a very loud report, attended with flame and a strong smell of sulphureous acid. When the sulphur was reduced to a quarter of a grain, the explosion was not made at once

as

as before, but succeſſively. When the proportion of ſulphur was increaſed to three fourths of a grain, it produced a very loud report, much the ſame as the firſt; and the whole appeared to explode at once. Equal parts of ſulphur and the ſalt did not cauſe ſo ſtrong reports as when a leſs quantity of ſulphur was employed: this mixture exploded ſucceſſively. The ſulphuric and nitrous acids inflamed it.

Experiment V. *with Sulphuret of Potaſh.* One grain of the ſalt rubbed with the ſame weight of this ſubſtance produced a very loud exploſion with flame. With half a grain of the ſulphuret I thought the report fully as violent. A little of theſe mixtures melted over the fire had not the effect of the fulminating powder made with nitre. It only emitted a flaſh without any report, nor was I able to produce a fulminating mixture by varying the proportions of the ſalt, alkali and ſulphur. The ſulphuric or nitrous acids dropped on this mixture gave a very ſtrong bright flame.

Experiment VI. *with Sulphuret of Mercury.* (*Cinnabar.*) Equal parts of this ſubſtance and of the ſalt detonated ſucceſſively by friction, a grain of each being uſed. A change of proportion appeared to weaken the detonating property of the mixture. The ſulphuric acid inflamed this mixture, but not ſo rapidly as in the laſt experiment. The nitrous acid did not inflame it.

Experiment VII. *with Sulphuret of Arſenic.* (*Orpiment.*) A grain or two of the ſalt rubbed with an equal weight of this ſubſtance produced little more than a flaſh; but a grain of the ſalt with half a grain of the ſulphuret gave a ſtrong report, though very little friction was uſed. Reducing the quantity of ſulphuret to a quarter of a grain, the exploſions were weak and ſucceſſive. A larger quantity of this mixture than is mentioned above makes a report which is very unpleaſant, with conſiderable flame. I was greatly ſurpriſed, the firſt time I made the experiment with two or three grains of the ſalt and a portion of the ſulphuret, by their exploding in a moſt violent manner, though a very ſlight friction had been uſed. The ſulphuric or nitrous acids gave a very ſtrong flame the moment they were dropped upon this mixture.

Experiment VIII. *with Cotton-wool.* A ſmall quantity of very dry cotton-wool was rubbed with a little of the ſalt; no detonation took place. The wool was afterwards dropped into the ſulphuric acid, and took fire immediately; but the nitrous acid would not inflame it.

Experiment IX. *with Loaf-ſugar.* One grain of this ſubſtance rubbed with two of the ſalt gave a number of ſucceſſive reports. The ſulphuric or nitrous acids dropped on this mixture inſtantly produced a ſtrong flame aſcending to a conſiderable height.

Experiment X. *with fixed and eſſential Oils.* A few drops of ſpermaceti oil rubbed with a grain or two of the ſalt produced a number of loud reports. The ſulphuric acid inflamed this mixture; the nitrous acid did not.

Olive oil, the eſſential oils of roſemary, juniper, cloves, carraway, aniſeed, cinnamon, nutmeg, amber, mint, and eſſence of lemon, were rubbed with the ſalt: all of them detonated ſucceſſively, and ſuch of the mixtures as were tried took fire with the ſulphuric acid.

Experiment XI. *with Spirit of Turpentine.* A few drops of ſpirit of turpentine rubbed with a little of the ſalt detonated in much the ſame manner as the ſubſtances uſed in the laſt experiment. The ſulphuric acid dropped on this mixture produced a ſtrong flame, with a cloud of very black ſmoke.

Experiment XII. *with Camphor.* A little of this ſubſtance on being rubbed with a grain of

of the salt produced a number of successive detonations. The sulphuric acid produced flame with some explosions.

Experiment XIII. *with Rosin.* One part of this substance with two parts of the salt detonated successively when well rubbed together. The sulphuric acid inflamed this mixture, but the nitrous acid did not.

Experiment XIV. *with Gum-Arabic.* The detonations were very slight. It was mixed with twice its weight of the salt. The sulphuric acid set fire to the mixture, but the nitrous acid would not.

Experiment XV. *with Prussian Blue.* No detonations whatever were produced by friction, nor did the acids inflame a mixture of this substance with the salt*.

Experiment XVI. *with Indigo.* Half a grain of fine Spanish indigo rubbed with a grain of the salt detonated successively, like the mixture with rosin or gum. The sulphuric acid inflamed this mixture, but the nitrous acid did not.

Experiment XVII. *with Ether.* A few drops of ether on about two grains of the salt rubbed to a very fine powder produced no detonation by friction. The sulphuric or nitrous acids poured suddenly upon it produced flame.

Experiment XVIII. *with Iron-filings.* These alone rubbed with the salt produced no detonation by simple friction; but two grains of the salt, one grain of iron-filings, and half a grain of sulphur, being well rubbed together, about a quarter of a grain of this mixture exploded violently with friction. The sulphuric acid added caused a few sparks to appear; but the nitrous acid did not produce any. Varying the above proportions did not appear to improve the detonating property of the mixture.

Experiment XIX. *with Aurum Musivum.* Equal parts of this substance and of the salt detonated strongly with flame, on being rubbed together in an iron mortar: a very slight friction was necessary. The sulphuric acid gave a small flame, but with the nitrous I could not procure any.

From the foregoing experiments I think we may venture to conclude, that the oxygenated muriat of potash is equally harmless as common nitre; except it be brought into an intimate union with something that has a greater affinity with one of its constituent parts, than exists between those parts when combined in the salt, and that some combustible substance be present: but its oxygen being so easily disengaged renders a little caution necessary; and as the sulphuric or nitrous acids seem so readily to inflame many of the mixtures, I would not advise any person to make more of them than is necessary for immediate experiment. This precaution may prevent any unpleasant circumstance from accidental mixture with the acids, which appear to disengage a great part of the oxygen almost instantaneously.

I shall not say much about the theory of these detonations, none of the foregoing experiments having been so carefully conducted as to determine accurately what changes took place; yet I think we may attempt to explain some of them in the following manner: With phosphorus the oxygen seems to combine, and form phosphoreous acid gas, or phosphoric acid; with sulphur, the sulphureous acid gas, or sulphuric acid, according to the rapidity of

* Chaptal (Elements of Chemistry, vol. ii. page 377,) says, "Prussian blue takes fire more easily than sulphur, and detonates strongly with the oxygenated muriat of potash. (Quære, Did he not make use of indigo here?)

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the combuſtion ; with charcoal and other vegerable ſubſtances, the carbonic acid ; with ſulphuret of arſenic there may be ſulpureous acid gas and arſenic acid produced.

The ſudden production of gas ſtriking the ſurrounding air, is moſt probably the cauſe of the loud reports produced by friction, &c. agreeably to the concluſions of Berthollet ; and the muriatic acid may remain combined with the potaſh, and a portion of the combuſtible ſubſtance employed : but, when the ſulphuric or nitrous acids are uſed, the muriatic acid is certainly diſengaged.

Since the above experiments were made, I have found that a paper has been read before the National Inſtitute of Paris, On detonation by concuſſion, by Citizens Fourcroy and Vauquelin *. They there mention ſome of the mixtures I have deſcribed, and their inflammation with the ſulphuric acid. They likewiſe notice, that very loud reports and ſparks were produced, on a very ſmall quantity of different mixtures being ſtruck with a hammer on an anvil. This on trial I found to be the caſe; and a little cotton wool well impregnated with the ſalt being ſtruck in that way immediately took fire. But, to get this to ſucceed, the ſalt and cotton ſhould be perfectly dry : this is a neceſſary precaution in all experiments on the detonating property of this ſalt by friction, &c. In the paper above alluded to it is ſtated, that ſugar, the gums, fixed and volatile oils, alcohol and ether, do not detonate or take fire by ſimple trituration : but the experiments I made ſeem not to agree with this aſſertion ; for all the above ſubſtances that I tried, except ether, detonated either more or leſs, on rubbing them briſkly in a ſtone-ware mortar ; ſome of them required to be intimately mixed, as ſugar and gum ; but others produced very loud reports, as when fixed and eſſential oils were uſed.

IV.

Obſervations on the Natural Hiſtory of Guiana. In a Letter from WILLIAM LOCHEAD, *Eſq. F.R.S. Edin. to the Rev. Dr.* WALKER, *F.R.S. Edin. Regius Profeſſor of Natural Hiſtory in the Univerſity of Edinburgh* †.

DEAR SIR,

ALLOW me at preſent to trouble you with a few general obſervations on natural hiſtory, which I had an opportunity of making while on a botanical excurſion, with my friend Mr. Anderſon, to the Dutch colony of Demerary. Guiana is a country but little known in Europe, though its animals and vegetables have added conſiderably to the catalogue of natural productions. It is not, however, the organic kingdom which I mean at preſent to touch upon ; all I aim at is, to give you ſome idea of the face of the country, as leading to the knowledge of its formation and preſent ſtate. It is not a field for the mineralogiſt, as its interior is unexplored. But to the geologiſt, who wiſhes to trace revolutions of the lateſt date, it is not unintereſting to contemplate ſuch a recent and ſingular country as Guiana.

I need not inform you, that under Guiana is comprehended all the coaſt of South Ame-

* Annales de Chimie, tom. xxi. p. 235. Nicholſon's Chemical Journal, i. p. 169.

† Edinburgh Tranſactions, iv.

rica,

rica, from the Amazons to the Oroonoko; that it trends nearly N. W. and S. E.; that it is in general a very low and flat country, eſpecially the Dutch or weſternmoſt part of it; and that it is watered by ſeveral rivers and creeks, which riſe in a chain of mountains running nearly E. and W. and dividing Guiana from the inland parts of South America, which form the banks of the Amazons and its numerous branches.

Coaſt.—No coaſt can be more eaſy to make than that of Guiana. The changed colour of the water indicates ſoundings long before you make the land, and you may run on in ſeven fathoms before you can diſcover it from the deck. The bottom is at that diſtance a ſoft mud. All along the coaſt near Demerary, you have only about two fathoms at a good league from the ſhore; to leeward of Eſſequebo, it deepens ſtill more gradually. In ſtanding off or on five or ſix miles, you will hardly deepen or ſhallow the water as many feet. When a high ſea ſets in upon ſuch a coaſt, it is eaſy to conceive that at a very conſiderable diſtance from the land it muſt be affected by the bottom. The interval betwixt wave and wave becomes more diſtinct. As they roll on in ſucceſſion, the lower part is retarded, the upper ſurface accelerated: each billow of courſe becomes ſteeper and more abrupt, till at laſt it gradually ends in a breaker, when it has come to the depth of only a few feet. Theſe *rollers* as they are called are the dread of ſeamen, eſpecially betwixt Eſſequebo and Pomeroon, where the water is ſhallow, and the bearing of the coaſt very much north and ſouth, and expoſes it fully to the action of the trade winds. In ſmall craft, thoſe acquainted with navigation do not heſitate to run along the coaſt, even among the rollers themſelves; but veſſels drawing from eight to twelve feet water, eſpecially if the ſwell be heavy and it falls calm, can hardly get off. If anchor and cables fail, they drift on till they are faſt in the mud, and there they will continue ſometimes for weeks together before they go to pieces. The ſea water becomes exceedingly thick and muddy within a few leagues from the coaſt of Demerary, as much or more ſo than the Thames is at London. A ſtranger would naturally take this for the diſcharge of large flooded rivers after a rainy ſeaſon. By and by I ſhall explain the true cauſe of it.

On approaching the continent of South America, a change on the face of the ſky will ſtrike the attentive obſerver. The clouds become leſs diſtinct from each other, and the intervals between them leſs clear. They are blended into one another as it were, and ſuffuſed more generally over the atmoſphere. They appear to be ſurcharged with vapour, or to have a ſtronger diſpoſition to depoſit it.

There is a particular prevailing appearance of the heavens within the tropics, when you are at a diſtance from continents or very high iſlands, which has ſo often ſtruck me that I wonder it has not been taken notice of. I call it a *tropical ſky*, and thus deſcribe it. The clouds in fine weather are in a ſingle ſeries or ſtratum, ſailing away regularly with the trade-winds. They are ſmall, and diſtinctly ſeparated from each other. The intervals or ſky above them of a clear azure. The lower ſurface of the clouds is perfectly horizontal. As the temperature is commonly very equal over the ſea, the condenſation takes place every where at an equal height from the ſurface of the water. In the clouds that are over head you cannot indeed perceive this; but it becomes more and more viſible as the eye recedes from the zenith. The lower limb of each diſtant cloud appears perfectly level and well defined, brighter than the ſuperincumbent part. At a diſtance nothing is to be ſeen but theſe limbs cloſer and cloſer in gradation, one behind the other; and the whole horizon round

round reſembles the roof of a ſtage with an infinity of half dropt curtains as far as the eye can reach. In two voyages from Europe, I have met with this tropical ſky as far north as Cape Finiſterre. It came with a fair wind, which continued with us like a regular trade wind, accompanied with the ſame appearance of the clouds till we made the Weſt Indies. In running down the trade winds, every one has an opportunity of verifying this deſcription, and muſt be ſtruck with the beauties which this ſky preſents at the ſetting of the ſun. The inhabitants of the lower iſlands may alſo be well acquainted with it. In the higher ones, the attraction of the mountains ever forms ſets of clouds of other appearances, as being produced by other cauſes. With our preſent knowledge of meteorology, hardly any other cauſe can be aſſigned for the phenomena above mentioned, than the conſtant equal temperature that every where prevails on the intertropical ſeas. One analogous fact however may be mentioned; the exceeding ſmall range of the barometer in the torrid zone. Does the ſame cauſe regulate ſo exactly the height of the clouds, and maintain the uniform ſuſpenſion of the mercury? We might almoſt ſuſpect it did, were it not well known that the barometer varies as little upon continents, and in the vicinity of mountains in theſe regions as elſewhere, though the condenſation of vapours is in ſuch caſes much more irregular. Upon the continent you will frequently obſerve this tropical ſky alſo, eſpecially in fine ſettled weather; but much more commonly you will find the ſky there, and even before you make the coaſt, covered with heavy large dark clouds in ſome places, and in others at a greater height, the ſerene dappled ſky ſo often ſeen in Europe.

Winds.—The *trade wind* generally prevails all the day long, and on the ſea coaſt ſeldom fails even at night; but in leſs than fifty miles up the river it is a dead calm at night, and the breeze is not able to penetrate ſo far till towards noon. Still farther up we had whole days of a ſtark calm, and the heat very intenſe.

Dews, fogs and temperature.—The dews, following the law which they generally obſerve, are very heavy when and wherever there is but little wind, and the hotter the day and evening they fall the more copiouſly; they were of courſe more abundant up the river than near the ſea-coaſt. The exhalations in the day-time from a hot and miſty country covered with vegetables being very great, the condenſation occaſioned by the abſence of the ſun and the cold accompanying that condenſation are in proportion. Near the coaſt, the diurnal difference of temperature is but trifling, the conſtant trade-wind preſerving in the air nearly the ſame medium of heat as in the body of the ocean; but far up the river the range of the thermometer was very great. The heat of the day was intolerable. In the ſhade it was frequently above 90°. This, when there is no breeze, forces you into the woods for ſhelter. Towards evening it cools; during the night the cold increaſes, and is greateſt about five in the morning. The thermometer would then be from 72° to 74°. The body of the river being large enough to retain its heat, the evaporation goes on from its ſurface through the night, and is condenſed into thick fog, which hangs over it, and is ſeldom diſperſed before eight or ten next day. While the air was as above in the morning at 72°, the water along ſide gave 80° to 83°, and ſeldom roſe two degrees higher at noon. We had an opportunity of verifying an obſervation made by the few inhabitants who live far up the river Demerary, that, when it feels very cool in the morning before day-break, they are ſure of fine weather; when, on the contrary, it feels warm, they expect rain. They

ſleep

ſleep in hammocks, and the houſes they have are pervious enough to the air; ſo they are ſenſibly affected by any change in its temperature.

Seaſons.—As to the ſeaſons, it is not an eaſy matter, from the accounts given by the coloniſts, to aſcertain them exactly. All ſeem to agree, that ſince cultivation has been ſomewhat extended they are not ſo regular as before; that the dry ſeaſon encroaches on the rainy, and that during the latter they have often ſeveral dry days in ſucceſſion. The account given by Dr. Bancroft was the one generally allowed; that it is dry about the equinox, and rainy about the ſolſtices; that of conſequence they have two wet and two dry ſeaſons every year. We thought it difficult to reconcile this with the account given of the ſeaſons of other countries in ſimilar climates, and with what actually takes place in the Carib iſlands. I will give you my ideas on the ſubject. It is within the tropics a very general rule, that the vicinity of the ſun brings the rainy ſeaſon. To the northward of the line, therefore, this muſt be our ſummer months. It is another invariable law, that as in lunar influences, ſo in the change of ſeaſons produced by the ſun, ſome time is neceſſary after the maximum of the cauſe to produce the full effect. The higheſt tides are not till two or three days after the full and change. The greateſt heat of the day is two hours afternoon, and the hotteſt months in Europe are July and Auguſt, not June, when the ſun is higheſt. Among the Weſt India iſlands the full effect of the ſun's vicinity is ſtill later. I have found Auguſt, and more eſpecially September, to be the hotteſt months in the year, and they are accordingly the height of the rainy ſeaſon. It begins thus: No ſooner has the ſun come to the northward, and begun to be vertical among the iſlands in April and May, than his force is felt, the ſky is more diſturbed, the wind is more frequently from the ſouthward and in ſqualls, and now and then there are heavy ſhowers. In June the ſame effects continue, and increaſe in July, when the proper rainy ſeaſon may be ſaid to begin, and continues in force more or leſs till the middle of October. Auguſt and September, with part of July and October, when theſe effects are at their greateſt height, are ſtyled the hurricane months, and by the French *l'hivernage.* During them the full force of the great luminary which diſtributes light and life, however neceſſary, ſeems ſometimes too much for nature. She is oppreſſed and ſickens; her reſpiration is diſordered by intenſe heat; ſometimes calms, ſometimes heavy ſqualls; the agitated elements vent themſelves in lightning, with thunder and torrents of rain, or are ſometimes thrown out into thoſe horrid convulſions, hurricanes, which ſeem to threaten inſtant diſſolution. Guiana is happily free from theſe ſcourges of the Antilles. Their force has lately been partially felt at Tobago, which was thought beyond their reach. In Trinidad, the greateſt ſtorms they have hitherto experienced do not deſerve the name of hurricanes; and to the ſouthward on the main of America they are utterly unknown. The difference then between Guiana and the iſlands is this: In the former, the rainy ſeaſon ſets in earlier, as indeed the ſun is ſooner vertical. Their principal rains are in the end of April, in May, June and July. They are alſo ſooner over; for Auguſt, September and October, and I believe part of July, are commonly fair weather. But again November, in part December, January and February, reckoned dry months among the iſlands, are in Guiana a ſecond rainy ſeaſon. The cauſe of this I take to be as follows: North-eaſterly winds prettty ſtiff, cold and bleak comparatively in theſe climates, are frequently among the iſlands during the winter months.

months. They are well known by the name of Norths. They are often accompanied with rain; but it is not very heavy, nor thought of conſequence enough to give the denomination of a rainy ſeaſon. Theſe winds we know to reach as far as the coaſt of Guiana; and there I have reaſon to believe they are productive of more rain than in the iſlands. The face of a large continent, and its effects upon the atmoſphere, may very probably make them give up more of their humidity than they do among the Antilles, though at the ſame time their force and bleakneſs may not be ſo much felt. If this conjecture hits the truth, the following ought to be the corollaries, and are left to future obſervation:—In this rainy ſeaſon, when the ſun is near the ſouthern ſolſtice, their rains will be with pretty ſteady northerly breezes on the coaſt. They may be of longer continuance at a time, but they will not be ſo heavy as thoſe of ſummer, and they will be chiefly on the ſea-coaſt, and probably will not extend a great way up the country. It remains even a query with me, whether the rain that accompanies the norths among the iſlands, eſpecially thoſe moſt remote from the line, be not generally in a greater proportion than is commonly ſuppoſed.

Country.—I will now endeavour to give you ſome idea of the face of the country. Though, as is well known, Guiana is flat and ſwampy, yet it affords to the attentive eye an intereſting variety. The ſea-coaſt is little if at all raiſed above the level of high water, and is continued at this level for many miles inland. It is properly an immenſe woody ſwamp, never dry in the drieſt ſeaſon, covered with ſeveral feet of water in the wet. Next the ſhore, as far as the brackiſh water extends, it is covered with mangroves, which grow to a conſiderable height and form a thick ſhade. They are elevated on their branchy intermingled roots from the bare wet clay or mud, on which there is ſcarcely one herb or plant, but which ſeems to be all in motion from the prodigious number of crabs which make their holes in it. Further on, when the under water is freſh, you meet with a new ſet of vegetables, principally ſmall trees, which from their ſituation are obliged to adopt the habits of mangroves, having the bottom of their trunks ſupported three or four feet above ground by their ramified roots. Several climbing plants are mixed with them. Arunis in great variety and profuſion emerge from the water, or embrace the ſtems of the trees; and ſeveral broad-leafed plants of the hexandria and triandria claſſes aſſiſt the arunis in forming an herbage. In all this low part of Demerary there is not one tree of a large ſize, nor among them all above two or three ſpecies which can be applied to uſe as timber. Proceeding ſtill up the river, its banks are found generally to raiſe themſelves above the level of the water; and when you have gone up one tide (betwixt twenty and thirty miles), they are ſo high that there is no farther occaſion for dams to keep the plantations from being overflowed at high water, as below: canals or ditches are ſufficient to drain the land, which is ſtill perfectly flat. The trees are here different in ſpecies and larger in ſize than below, and the woods are much more practicable. As they are drier, the ground has acquired a regular ſort of ſurface, and there is neither that plexus of roots nor the ſame number of vines (the common name in the Weſt Indies for all climbing plants) to entangle thoſe who chooſe to traverſe them. The ſoil here is generally a ſtiff, cold, reddiſh clay, mixed a-top with a portion of vegetable mould.

The ſand-hills preſent to the admiring eye a ſcene very different from what it had been accuſtomed to below. The firſt you meet with upon the Demerary is upwards of thirty miles from the mouth of the river, and on the right hand aſcending, or on its weſtern ſhore. There

There are of them further down in the country, but not cloſe to the river ſide. This one is the extremity of a ridge which extends to the weſtward ſeveral miles. As you aſcend the river you meet with many more of the ſame kind on both ſides, whoſe direction ſeems likewiſe to be eaſt and weſt, or nearly at right angles with the average courſe of the ſtream. They vary from 50 to 100, 150 or 200 feet of perpendicular height above the level of the river and the intervening flat country. Their breadth and extent vary ſometimes only a few hundred paces, ſometimes many miles. Their length is great; with ſome interruptions, I have reaſon to believe they are generally continued from one ſide of the colony to the other, only interſected in different places by the rivers and their branches. They conſiſt of a pure ſiliceous ſand, ſo white that it dazzles the eyes, commonly fine-grained and looſe, but not unfrequently mixed with little ſtrata of coarſer pebbles, moſtly quartz, and ſometimes concreted into a proper ſand-ſtone. In the laſt caſe, a black or reddiſh tinge is in many caſes communicated to it from clay, decayed vegetables, or other extraneous matter. There is no regular ſtratification to be found in it, more than what is common to all ſands the produce of depoſitions of different dates; and, as they are of different materials, thicker in one place, thinner in another, ſometimes horizontal but oftener inclined, and convex or concave according to circumſtances. We could meet with no appearance of ſhells or other marine productions, but in a few places pieces of broken vegetables buried in the ſand where it was concreted. They were black, as all the foſſil vegetables that I have ever ſeen in ſand-ſtone. Upon and by the ſides of the ſand-hills grows the moſt valuable timber of theſe colonies. The trees there are of a good ſize, and very clear of obſtructing underwoods or vines. The wallabba (parivoa grandiflora of Aublet); the ſipiri or green-heart (a new ſpecies of laurel); the coumarou or tonquæbean tree, coumarouna odorata of Aublet; the mora, valuable for boat timbers; and many others whoſe wood is equally hard and beautiful.

Continuing to aſcend the river, the ſand-hills become rather more frequent; but the intervals ſtill remain a perfect flat, though now ſeveral feet above the level of the ſtream, and the ſoil is ſtill a ſtiff clay. Hitherto the river is deep all over, generally from two to five fathoms; the bottom is mud or clay, and the ſhores on either ſide at low water covered with ooze. About 130 miles up, however, or juſt before it begins to ſhallow, the bottom is covered with banks of a hard white or brown ſand. It was a problem for ſome time, whence all this ſand originated in ſuch a country. It was ſoon ſolved. Leaving here the veſſel that had hitherto carried us, we proceeded in a canoe; and at about 160 or 170 miles diſtance from the mouth of the river we met with the firſt proper hills of ſolid materials. The neareſt to us was a rock of granite projecting into the ſtream, whoſe direction it gave a change to at this place; and it ſerved for a landing-place to the higheſt piece of cleared land upon the river next to the poſt-holders. It was part of a low ridge of the ſame ſtone which croſſed the country probably to Berbia or beyond it, and was ſucceeded by many other ſeries of hills more inland, and, as far as we could examine them, of the ſame materials. The granite was both of the red and the gray kinds, but chiefly of the latter. A number of ſeams or dikes croſſed it here and there in all directions, not diſtinctly ſeparate, but firmly united to the reſt, making as it were but one body with it, and conſiſting of the ſame materials differently modified. Their component parts were generally ſmaller; they were more compact and cloſer in the texture than what ſurrounded them; and where they had

had been equally expofed to the action of the weather, they appeared to have borne it much better than the furrounding granite. The origin of the fand was now accounted for. This ftone, in fome cafes exceedingly firm and durable, is in others very liable to decay; and the wafh of thefe enormous chains of hills was able to furnifh abundance of fuch fand as we had met with below. The granite afforded many varieties; indeed, every fhade from large and diftinct grained to that whofe component parts of feltfpar, fchorl, or quartz, were fo fmall as to refemble pretty compact compound lavas, or fome of our mixed whin-ftones in Scotland. All thefe varieties would be found at no great diftance from each other. I brought fome fpecimens from Tiger's Berg, a hill about 500 feet perpendicular height, which have every appearance of having undergone the action of fire. They refemble half vitrified fcoriæ, and would be taken for them, but that they were actually broken off from the granite, and difcover all its parts in the fracture. The fummit of this hill is irregular, with feveral pits and holes among the rocks. A little higher than it, and I fuppofe nearly about 200 miles from the fea, you meet what are called *the falls*. They are only five or fix rapids within the fpace of a mile or two, formed by ledges of very clofe-grained gray granite that run acrofs the river. There are breaks in each of them, through which the dextrous Indians are able in their light canoes to pafs up at any feafon, even the drieft; and when the river is fwelled by the rains they become totally obliterated. Two days journey or two and a half above this is the great fall, where the ftream comes over the face of a rock, as we are informed, twenty feet high.

Savannahs.—Savannahs, ever fince the difcovery of America, have been known to occupy large fpaces in the fouthern parts of that continent. They are to be met with abundantly in Guiana, and are of two kinds very diftinct from each other, the *wet* and the *dry*. Of the former many are extenfive as the eye can reach—immenfe verdant plains occupying the whole face of a country, with or without a few ftraggling infulated patches of wood. In the dry feafon they appear meadows of long grafs or reeds, and are feldom practicable for any diftance, for the bottom is very rarely dry. In the wet feafon they are all one entire plain of water, over the furface of which the grafs ftill rifes, but which may be every where navigated in the couriалls or canoes. Towards the end of the drought the Indians fet fire to them. The young growth which fucceeds attracts the deer; and the native, on the return of the half deucalion days, purfues them in his little bark acrofs their former plains. The foil upon thefe favannahs can neither be very deep nor very good; yet water may be always commanded, and labour and induftry might convert thefe deferts into rice fields. It is a queftion whether the days of flavery will ever fee that event. The culture of this ufeful vegetable, which in the eaft has for ages been the ftanding food for millions, brings too moderate a return, at leaft in an infant colony, for the rapacious agricultural fyftem of the Weft Indies.

The dry favannahs are neither fo frequent nor fo extenfive, yet we have paffed through fome of them feveral leagues in circumference. They are formed along the flats on the top of the fand ridges, and covered by a very thin coat of verdure. They refemble exactly enough fome of the bare moors in Scotland. Many beautiful plants of the clafs gynandria are their chief ornaments, as is alfo the orchis, which grows in fimilar fituations with you. Some melaftomas and more rhexias fupply the place, and bear fomewhat of the habit of the ericæ; for your fedums and faxifrages is the little fauvagefia; and, in hollows of the fame

same savannahs where moisture prevails, what I never could have expected to see within five degrees of the line, and not more than 50 or 100 feet above the level of the sea, the drosera lifts its humble head from a bed of the sphagnum palustre.

[To be continued.]

V.

On the Sugar Maple. By Citizen TESSIER *.

SUGAR is one of the most common products of the vegetable kingdom, and is found ready formed in a great number of species. It is obtained from the wild cherry-tree, (merisier), the poplar, the birch, the nut-tree, the pods of gleditzia, maize, the asclepias syriaca, &c.; but the tree which next to the sugar-cane affords this product in the greatest abundance and best quality is the sugar maple (acer saccharinum).

Many species of maple grow naturally in France, Germany, Switzerland, and England. The acer opalus is found particularly in Italy, and that which Linnæus distinguishes by the name of acer tataricum in Asia. But America is the country of most of the sugar maples. It was from Quebec that Mr. Sarasin forwarded this tree to the *Jardin des Plantes*. Father Charlevoix, at the distance of a league and a half from Quebec, was regaled, to use his own expression, with the saccharine juice of maple. Kalm, at the post of Three Rivers, between Montreal and Quebec, saw the process of making sugar with the sap of the maple. The acer saccharinum is there so common that it is used for fuel.

A climate in which the winters are long and severe is best adapted to the sugar maple. I do not know whether it is found in a more northerly latitude than that of Canada. In that country, though situated in the latitude of about 44°, the cold lasts longer, and is more intense than in France, on account of the enormous masses of water, the woods and the mountains. Towards the south, the maple becomes very rare, so that few are seen beyond the lower part of Louisiana. Kalm has remarked, that they grow to a less height in the southern parts of the United States than in Canada, and that they do not grow in New Jersey and Pennsylvania, except on the sides of the Blue Mountains, and the steep banks of rivers exposed to the north. And even in this exposition they do not obtain more than one third or a quarter of the height they acquire in Canada. The intelligent Dupratz, author of the History of Louisiana, confirms what Kalm has advanced. The species of maple which we possess in France do not thrive excepting in places where the cold is of long duration. Kalm assures us, that being in the neighbourhood of Chester, a small town on the Delaware in Pennsylvania, he saw red maples on a marshy soil accompanied by the alder—an observation which points out the soil in which this tree ought to be planted. The sugar maple is also found in the State of Vermont in Kentucky, in the country beyond the Ohio, opposite to Pennsylvania and Virginia. According to the author of the American Geography, sugar is made from it in these countries; but it does not seem to be an object of great interest, as the author of that geography simply mentions the fact.

* Inserted in the Annales d'Agriculture, and thence copied into La Decade Philosophique, &c. No. 9, an vi. from which last work the present translation is made.

Citizen Michau, nurferyman at Charles Town, has a confiderable quantity near the banks of the Ohio in the ftate of Virginia, beyond the Apalachian mountains. They were planted in a good foil. In this country the maples have fuch a growth, that, if the author of the American Geography may be credited, fycamores are to be met with forty-four feet in circumference *.

The Canadians have long been accuftomed to ufe the juice of the maple as a refrefhing beverage. When it iffues out of the tree it is clear, whitifh, and of a cool faccharine tafte. By expofure to the fun in fummer, it is converted into good vinegar. It is obtained by boring the trunk of the tree, taking care to direct the inftrument upwards. The blade of a knife, or a piece of thin wood in the form of a ruler, is inferted to conduct the fluid to a veffel placed beneath for its reception: without this precaution, it would flow down the bark of the tree and be loft. Mr. Gaultier obferves, that the perforation muft be made into the proper ligneous circles, and that the faccharine juice is not to be obtained by making incifions in the middle bark or the liber, or at leaft that the quantity obtained will be very fmall. At the commencement of the thaws the fap flows abundantly for about three weeks; after which it thickens and entirely ftops. The maples afford more fap the greater the quantity of fnow has been, and the more rigorous the winter. The moft favourable period is when the fnow begins to melt, and the cold weather ftill continues. The flow is confiderable in the fpring, when the thaws are great and decided. The colder the nights, the greater the quantity of fap which flows on the following day. It feldom flows during the night, unlefs the weather be mild. If thefe obfervations had been made in all parts where there are fugar maples, they would afford reafon to conclude, that the regular alternation of great cold during the night and very perceptible heat during the day-time, which takes place in the northern parts of America, contributes to elaborate the fap of the maple and render it fweet.

The juice of the maple is collected earlier or later according to the country. In the vicinity of Quebec, Three Rivers, and Montreal, it lafts from the middle of March to the middle of May, when the fun begins to have power; but near Lake Champlain it is collected from the middle of February to the early part of March. In this country the thaws commence about the end of January.

If we give credit to Mr. Gaultier, the French taught the favages to extract fugar from the fap of the maple; but if we depend on Kalm, the favages knew this art before the Europeans had difcovered America, and the latter people have only followed the practice of the favages. Whatever may be the value of thefe two unfupported affertions, it is certain, that in order to extract this fugar the liquor is boiled over the fire, taking care to ftir and fkim it until it has obtained a very thick confiftence. If it be kept too long over the fire, it acquires a tafte of honey like melaffes. This fugar becomes fpontaneoufly purified. It is fometimes clarified with whites of eggs before it is fufficiently boiled, and after the clarification the ebullition is continued: when the boiling is fufficient, the fugar is poured into a veffel which gives it its form. In Canada, wherever the maples abound,

* This appears to me to be greatly exaggerated; the largeft American fycamores, according to the report of perfons who have meafured them, being no more than from twenty to twenty-four feet round. *Note of the Author.*

they

they make this ſugar, as, in France, cherry brandy is made in ſuch places as abound with cherries.

The firſt juice which is extracted from the maples in the ſpring is ſweeter than that which flows at the end of the ſeaſon, when it has the taſte which in Canada is called the taſte of the ſap. This laſt, from which the ſugar is more difficultly extracted, is kept in the ſtate of ſyrup. It contains more ſugar in proportion as the weather is colder. Trees of the ſame age do not afford the ſame quantity either of ſap or of ſugar, neither do the quantities of ſugar in like quantities of ſap agree. That of the old maples, which is leſs abundant, is more ſaccharine. The ſap of maples which grow in a mountainous and ſtony ſoil is more ſaccharine than that of ſuch trees as grow in low humid ſoils. This obſervation holds good with regard to all vegetable productions.

A tree of three or four feet in circumference may afford from thirty to ſixty pints of liquor, and ſometimes more; and a pound of ſugar is about the quantity obtained from ſixteen pints, that is to ſay, nearly three pounds of ſugar per tree. Care muſt be taken to make the openings on the ſame ſide every year, in order that the tree may not die. The ſouth or ſouth-weſt is the proper ſide. Mr. Gaultier obtained in a quarter of an hour a pint of this ſaccharine fluid from a perforation three inches deep, made on this ſide of a tree four feet in circumference; at the ſame time that a perforation in the ſame tree on the north and north-eaſt afforded him only a chopine or half pint in the ſame time. If the perforations be multiplied the tree becomes exhauſted, and its old age is accelerated. It ſeems to me that it would be adviſable to leave the tree untouched every ſecond year, in the ſame manner as good economiſts ſuffer their mulberry trees to repoſe at like periods.

Father Charlevoix cauſed a refiner at Orleans to make a trial to refine the maple ſugar. He found ſome difficulties in the attempt; but with attention theſe difficulties have been ſurmounted, for it is at preſent refined in America. This ſugar, in the ſtate we uſually receive it from that country, may be kept a long time without alteration, as I have ſeen in a piece in the collection of Citizen Juſſieu.

Gaultier and Kalm affirm, that the maple ſugar of the ſavages of Canada is mixed with flour, whether to render it more nutritious or to augment the quantity; but this kind of ſophiſtication, if the maple ſugar ſhould become an object of commercial intereſt, would be eaſily diſcovered. Such ſugar is whiter than other ſamples not ſo adulterated.

The ſugar of the maple is employed by the inhabitants of the remote parts of Canada, for the ſame uſes as the ſugar of the cane with us, becauſe they are poor; and this ſugar, though leſs pleaſing to the ſight and taſte, coſts them nothing but the trouble of tapping the trees and evaporating the fluid. This ſugar is more difficultly ſoluble in water; and its ſweetening quality, if I may uſe this expreſſion after Kalm, is to that of the ſugar-cane as one to two. The richer inhabitants of towns which by commerce have intercourſe with the colonies where the ſugar-cane is cultivated, prefer for their ordinary conſumption the ſugar of this laſt plant, and uſe that of the maple as an agreeable medicament. It is particularly recommended for coughs and colds, and its uſe is even preſcribed for diſorders of the lungs.

It is eſtimated that between twelve and fifteen thouſand pounds weight of maple ſugar is annually made in Canada. It is the product of four or five thouſand trees. From this fact, ſuppoſing an arpent of land of a hundred perches, at eighteen feet the perch, planted with

with maples in full growth, each affording ſixty pints of liquor, the product would be ſix hundred and ſixty-ſix pounds of unrefined ſugar. For the arpent may ſupport two hundred and twenty-two trees, placing the ſtems at twelve feet diſtance from each other.

The maples begin to afford a certain quantity of ſugar at the age of 18 years, and ceaſe to afford any at 60 or 70 years. In America, thoſe trees are reckoned large which riſe above 60 feet. There are ſome which are two feet in diameter. The wood of certain ſpecies is hard, and of a cloſe texture. If they be tapped too ſoon, there is reaſon to fear that it may injure the growth, and render the product of ſugar inconſiderable. It is therefore of advantage to determine the period of life at which the tapping ought to be commenced. And on this head it has been aſcertained, that the beſt and moſt abundant produce is obtained from trees of the middle ſize, and that ſcarcely any is afforded by maples which are large and old.

The ſugar maple has not hitherto been cultivated in France, but as an object of curioſity. Some enlightened cultivators, who endeavour to direct all their purſuits to objects of utility, have entertained the hope that ſome advantage might be derived from this tree. There are a ſufficient number of theſe trees at preſent in France, to afford the means of determining whether they produce ſugar in our climate, and in what quantity; and this deciſion is neceſſary to be had before the cultivation in the large way ought to be propoſed. For it is poſſible that they may afford a very ſaccharine liquid in America, and much leſs in Europe, as happens with the liquid amber; which, according to Kalm, affords much balſam in New Mexico and South Carolina; but produce leſs in Virginia, and none at all in Penſylvania and New York.

The difference which exiſts between the cold of the nights in the American countries and thoſe of Europe under the ſame degrees of latitude, the heat of the ſun being equal, muſt neceſſarily influence the progreſs of vegetation.

In the mean time, until we ſhall acquire the neceſſary information, if it ſhould be thought fit to increaſe the number of theſe trees, the following is the method of proceeding:—The ſureſt and moſt uſeful is to ſet the ſeeds. They may be found in the plantations of M. Duhamel, M. Les Maleſherbes, and ſeveral other curious gardeners. It is obſerved, that the acer ſaccharinum brought from America is not raiſed but with difficulty, either becauſe it is not tranſplanted at the proper time, or becauſe it has failed of receiving proper care during the paſſage. It would perhaps be neceſſary to ſend expreſsly to America an intelligent gardener, or to give inſtructions in the country to an attentive perſon to ſend the beſt ſeed to France, and even the plant, in order to accelerate our progreſs. The acer ſaccharinum never grows from ſlips; but it grafts very well on the ſycamore. Its reſemblance to the plane maple of Europe, which is ſuch that the two trees are confounded, ſeems to ſhew that it would be moſt convenient to graft upon this tree; but a gardener has ſeveral times attempted this in vain. An opaque matter which lies between the wood and the bark oppoſes the union. The maple negundo, the only one which is multiplied by ſlips, is likewiſe propagated by ſeed and by layers. The jaſper maple is grafted with the greateſt ſucceſs on the ſycamore. It riſes with a better ſtem when grafted in this manner; but care muſt be taken to graft very low. Ripe ſeeds of the red maple have not yet been obtained; but it may be raiſed from American ſeed, and in this manner

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the two individuals may be obtained. The acer tomentoſum, laſtly, is one of thoſe which is moſt eaſily multiplied in our climates.

Though it is ſaid that ſome ſpecies of maple may grow in light ſtoney ſoils, they proſper better in good ground. The ſoil of the mountains cannot always be conſidered as bad. The red maple delights in the plains and valleys, and all the ſpecies are injured by a ſtrong ſun. They ſucceed well if ſheltered to the ſouth by mountains or woods, as I conclude from the ſtate of the ſugar maples of Maleſherbes and Rambouillet.

The advantages which would reſult from cultivating the ſugar maples in Europe, and particularly in France, are relative to the quantity of ſugar they may afford. When it ſhall be proved that a great quantity, or at leaſt ſeveral pounds per tree, can be obtained, lands which are even ſuſceptible of cultivation will be devoted to this object. Some ſpecies will require to be placed on the ſlopes of mountains, where the ſnow and cold weather prevail for a long time. Others will be planted in low ſituations on the borders of meadow lands, lakes, rivers, and grounds approaching to marſh lands, ſuch as thoſe where the alder delights to grow. Such plantations, which may contribute to increaſe the production of ſugar without any other care than that of tapping the trees and concentrating the liquor, will be of great utility in ſupplying our habitual want of this article. Beſides which, the ſugar maple preſents to turners, muſical inſtrument makers, inlayers, the workers in ſtaining wood, and gunſmiths, a valuable material, which in ſome of the ſpecies is veined and marbled. It is proper, therefore, to encourage the growth of this tree.

In addition to the facts and obſervations contained in the foregoing memoir, which, if concluſive with reſpect to France, would probably be much more ſo with regard to the northern diſtricts of our iſland; it may be added, that Dr. Benjamin Ruſh of Philadelphia communicated an excellent paper on the ſame ſubject to the American Philoſophical Society, which was publiſhed in their Tranſactions, vol. iii. in the year 1793. The abſtract of his paper is as follows:

The acer ſaccharinum of Linné, or ſugar maple tree, grows in great quantities in the weſtern countries of all the middle ſtates of the American Union. It is as tall as the oak, and from two to three feet in diameter; puts forth a white bloſſom in the ſpring before any appearance of leaves: its ſmall branches afford ſuſtenance for cattle, and its aſhes afford a large quantity of excellent pot-aſh. Twenty years are required for it to attain its full growth. Tapping does not injure it; but, on the contrary, it affords more ſyrup, and of a better quality, the oftener it is tapped. A ſingle tree has not only ſurvived, but flouriſhed after tapping for forty years. Five or ſix pounds of ſugar are uſually afforded by the ſap of one tree—though there are inſtances of the quantity exceeding twenty pounds. The ſugar is ſeparated from the ſap either by freezing, by ſpontaneous evaporation, or by boiling. The latter method is the moſt uſed. Dr. Ruſh deſcribes the proceſs, which is ſimple, and practiſed without any difficulty by the farmers.

From frequent trials of this ſugar, it does not appear to be in any reſpect inferior to that of the Weſt Indies. It is prepared at a time of the year when neither inſect nor the pollen of plants exiſts to vitiate it, as is the caſe with common ſugar. From calculations

tions grounded on exifting facts, it is afcertained that America is now capable of producing a furplus of one eighth more than its own confumption; that is, on the whole, about 135,000,000 pounds, which in the country may be valued at 15 pounds weight for one dollar. Dr. Rufh mentions many other benefits his country may derive from this invaluable tree, and concludes his paper with an account of fome of the advantages of fugar to mankind; not merely, as commonly confidered to be a luxury, but as an excellent wholefome and nourifhing article of food. Annexed alfo is an extract from the report of the committee of the Britifh privy council on the fubject of the African flave trade, containing Mr. Botham's ftatement of the mode of cultivating a fugar plantation at Batavia *.

VI.

The Progrefs of Mechanical Difcovery, exemplified in an Account of a Machine for cutting Files. (*W. N.*†)

THE folly and confequent diftrefs of purfuing experiments in chemiftry, for the fole purpofe of commercial advantage, has been repeatedly obferved both by public writers and in private life. The obfcurity which attends the proceffes of this art, the imperfections of theory, and the feductions of hope, have united to lead men in purfuit of medicines of uncommon powers, and agents which fhould convert the cheaper metals into gold and filver. It is a fubject of no wonder, to thofe who have not fuffered their mental habits to be vitiated by thefe feductive analogies, that difficulties and difappointment fhould attend the life of a man thus employed. But mechanics have, in general, been more favourably regarded. A number of fimple and admirably ufeful effects are produced by the operation of machines. We daily fee improvements produced by means eafily underftood. The mechanic who endeavours to ftrike into a new path, finds he can reafon from what has been done before him, and ufually begins his work with a conviction that the refults he is defirous of obtaining will infallibly happen. Hence it is that a prodigious number of new fchemes find their way into books; on which both the author and the reader fet a high value, and of which the futility is difcerned only by a few practical men. Some of my readers have fuppofed this fource of information to be much more productive than it really is. A very flight enquiry concerning new machines and inventions, whether they have been carried into effect, and whether they have fuperfeded the old methods of operation, will immediately ftrike out of the lift of valuable articles not lefs than nine tenths of the objects to which the public attention is folicited. And if it be afferted that the defcription of fuch abortive projects might be of ufe to afford hints to fpeculators, I muft take the liberty to obferve, that it is a moft ferious thing to engage in a new invention, and a no lefs ferious duty in the editor of a public work to

* To avoid the imputation of plagiarifm, I muft take notice that the two laft paragraphs appeared in an anonymous publication in the year 1794, but were written by myfelf. N.

† As the obfervation on the wrapper, *that all papers without name or fignature are written by the Editor,* has been overlooked by fome readers, who have made enquiry refpecting the authors of fuch papers, he has thought it expedient in future to add his initials.

be well assured of the value of what he recommends or suffers to recommend itself to his readers. From views of this kind, it has appeared to me, that I should do some service to an active set of men, some of whom have effectually served this country, if I were concisely to point out the course of mechanical invention, in order that those individuals only may be induced to engage in it, who possess the acquisitions and means to do it with some effect.

We will therefore suppose a very acute theorist, who is not himself a workman, nor in the habit of superintending the practical execution of machinery, to have conceived the notion of some new combination of the mechanical powers to produce a determinate effect; and for the sake of perspicuity, let us take the example of a machine to cut files*. His first conception will be very simple or abstracted. He knows that the notches in a file are cut with a chizel driven by the blow of a hammer, by a man whose hands are employed in applying these instruments, while his foot is exerted in holding the file on an anvil by means of a strap. Hence he concludes, that it must be a very easy operation to fix the chizel in a machine, and cause it to rise and fall by a lever, while a tilting hammer of the proper size and figure gives the blow. But, as his attention becomes fixed, other demands arise, and the subject expands before him. The file must be supported upon a bed or mass of iron, of wood, of lead, or other material:—it must be fixed either by screws or wedges, or weights, or some other effectual and ready contrivance:—and the file itself, or else the chizel, with its apparatus for striking, must be moved through equal determinate spaces during the interval between stroke and stroke, which may be done either by a ratchet wheel or other escapement, or by a screw. He must examine all these objects, and his stock of means in detail; fix upon such methods as he conceives to be most deserving of preference; combine, organize, and arrange the whole in his mind; for which purpose solitude, darkness, and no small degree of mental effort, will be required:—and when this process is considerably advanced, he must have recourse to his drawing board. Measured plans and sections will then shew many things which his imagination before disregarded. New arrangements to be made, and unforeseen difficulties to be overcome, will infallibly present themselves. The first conception, or what the world calls the invention, required an infinitely small portion of the ability he must now exert. We will suppose, however, that he has completed his drawings. Still he possesses the form of a machine only; but whether it shall answer his purpose, depends on his knowledge of his materials. Stone, wood, brass, lead, iron forged or cast, and steel in all its various modifications, are before him; the general processes of the workshop by which firmness, truth, and accuracy, are alone to be obtained; and those methods of treatment, chemical as well as mechanical, which the several articles demand:—these and numberless other practical objects call for that skill and attention, which may either lead to success, or, by their deficiency, expose him to the ignorance or obstinacy of his workmen. If he should find his powers deficient under a prospect so arduous—if he

* Transactions of the American Philos. Society, vol. ii. or Repertory, v. 184. The file is fixed on a bed of lead, and a chizel fixed at the end of a lever, is struck down with a hammer. This lever rises again of itself by means of a spring, and during its rise it moves a ratchet wheel, connected with the support of the bed; which consequently it shifts together with the file after every stroke.

cannot submit to the severe discipline of seeing his plans reversed, and his hopes repeatedly deferred—if unsuccessful experiment should produce anguish without affording instruction, what will then remain for him to do?—Will he embitter his life by directing his incessant efforts, his powers and resources, to a fascinating object, in which his difficulties daily increase; or, will he make that strong exertion of candour and fortitude, which will lead him to abandon it at once?

These are the inevitable stages of operation, through which every inventor in mechanics must pass. To the mere habit of viewing objects in new lights, the habit which leads to the outline of invention, he must add the power of disposing his notions in the form of an individual engine or instrument; and he must himself become a workman, capable of discerning the means by which his ideas may become realized in the proper materials. It may perhaps seem as if I had selected an instance of difficulty, and indulged my imagination in a sketch of obstacles seldom likely to be met with. This, however, is far from being the case. Nothing seems more simple and easy at first sight, than to make an engine to cut notches in a piece of steel; and a very ingenious person, in the work above referred to, has accordingly given an accurate design of an engine for that purpose, which no doubt he thinks must succeed. But manufacturers well know the value of such an engine, and have long ago attempted to make it by that and various other methods without success. That engine in particular, promising as it appears, is utterly incapable of working, for several reasons, scarcely to be discovered but by practical men, but which cannot with sufficient brevity be here detailed. And with regard to general obstacles in the detail of inventions, I am so far from magnifying them, that I am warranted by much experience, as well on my own behalf, as that of others whose plans and operations have come before me, to affirm, that no mechanical invention really new was ever brought to its complete or perfect state, at so small a charge as three times the cost of the finished engine, exclusive of the incalculable labour of the contriver.

VII.

The Dutch Process for making the Blue distinguished by the Name of Turnsol.*

LICHEN, Archil, or in case this last cannot be obtained, the greater moss of the oak, is dried, cleaned, and pulverized in a mill, resembling the oil mill, and then sifted through a brass wire sieve, the interstices of which do not exceed one millimetre in width (1-250th of an inch). The sifted powder is then thrown into a trough, and mixed with an alkali called vedas, which is nothing else but the cendres gravelées in powder. The proportion is one part by weight of the alkali, to two parts of the pulverized vegetable. This mixture is moistened with a small quantity of human urine; the urine of other animals does not contain a sufficient quantity of ammoniac. The mixture ferments, and is kept moist by successive additions of urine. As soon as the materials have become red, they are transferred into another trough, where they are again moistened with urine, and stirred to renew the fermentation. Some days afterwards the paste acquires a blue colour, in which state it is carefully mixed with one third of excellent pot-ash well powdered; and with

* From the Journal du Commerce, copied in the Decade Philos. &c. No. 57.

with this new mixture certain trays are filled, which are one metre (39⅓ inches) deep, and eight decimetres (31½ inches) wide. When the fermentation which takes place for the third time has given the paste a considerably deep blue colour, chalk or powdered marble is added, and the whole is well and perfectly mixed. This last addition is made, not to improve the quality of the blue, but to add weight. It is merely an affair of profit. The blue thus prepared is put into iron moulds 32 centimetres long and 22 square at the end (1¼ inch by $\frac{8}{10}$ of an inch). The moulded pieces are then placed upon deal planks, in well-aired lofts, to dry; after which they are packed in casks for sale.

The Hollanders made a secret of this process: and in order to mislead, they have published, that the blue was made with rags coloured by the plant turnsol; whence it has obtained its denomination *. We may derive much profit by carrying this discovery into practice.

VIII.

Experiments and Remarks on certain Ranges of Colours hitherto unobserved, which are produced by the relative Position of plain Glasses with regard to each other. (W. N.)

THOSE ranges of colours which are afforded by the reflection and transmission of light through thin transparent plates, have been an object of much attention to philosophers, ever since the experiments made by Robert Hooke and Sir Isaac Newton. The latter of these philosophers endeavoured to generalise the facts by a statement, which, because in part hypothetical, has been treated with contempt by some eminent men, though it has been referred to in most disquisitions on these phenomena. When a convex lens is applied to a plain glass, it is well known that coloured circles surround the place of contact; and as these circles are found to vary in their dimensions, the nearer the glasses lie with respect to each other, whether by means of the curvature or of pressure, it has been concluded that the effects are caused or governed by the distances of the surfaces. From various considerations Sir Isaac was led to conclude, that the rays of light are themselves possessed of a property, by which, in certain equidistant points of their length, they are disposed to enter transparent bodies, and in certain other points, intermediate between these, they are disposed to be reflected. From this assumption he deduced, that if a ray of light passed through the first surface of a medium, it would be either transmitted or reflected at the second surface, accordingly as the distance might happen to coincide with a point of transmission or reflection. According to this doctrine, it must follow that the interval will govern the effect, not in consequence of its own magnitude, but of the precise number of measures, or, as he calls them, fits of transmission or reflection it may contain.

Thus, for example, if we suppose a ray of indefinite length to be divided into equal parts, and imagine certain marks of division to subsist; if the ray pass, through the first surface of a medium exactly at one of these marks, it will be transmitted through any surface, however distant, which shall be remote from the first, either nearly or accurately some precise number of parts; because the fits of transmission are respectively at those points or marks: and

* English writers have used this denomination. But the dry-salters, or dealers in drugs, distinguish these pastils by the name of litmus.

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on the other hand, it will be reflected from any furface whofe diftance is meafured by fome number of whole parts, together with half a part; becaufe the fits of reflection lie half-way between the divifions. In this ftatement I have merely enunciated what are fuppofed to be the facts, and have not attended to his fuppofition of an etherial elaftic fluid, pervading all fpace and thrown into undulations more rapid than the velocity of light itfelf. Neither can I at prefent enter into any difcuffion concerning its probable value. My prefent object is to relate a few experiments, which, at the fame time that they fhew the exiftence of thefe fits at very confiderable intervals, appear to prove that the reflection and tranfmiffion of light in the fame medium is governed by other circumftances as well as by the diftance between the confines or furfaces. Thefe experiments lead to many fpeculations and extended paths of enquiry. It has long been my intention to multiply and repeat them, in order to difcover the laws upon which they depend: but other avocations have already delayed the accomplifhment of this purpofe for more than feven years; for which reafon, I hope that my defire to fee the object purfued by others may operate as an apology for the imperfect ftate of the refearch, of which I here prefent the commencement.

The experiments of the Abbé Mazeas on colours produced by applying flat plates of glafs to each other, are related at full length in Prieftley's Hiftory of Light and Colours, p. 499. This philofopher found, that rubbing the glaffes together caufed the colours to appear at the fame time that adhefion took place between them, and Mufchenbroeck found that lenfes of long focus do not afford colours after having been laid by for a length of time unlefs they be wafhed and wiped. One of the moft remarkable circumftances in the experiments of Mazeas was, that the colours of his flat plates are moveable by a very flight increafe of temperature; which produces an effect fimilar to what would have arifen from removing the glaffes further afunder, or diminifhing the preffure which might have been applied to them. Beccaria was, I believe, the firft who obferved that thefe colours may be produced by fuperinducing an electric charge on the external furfaces of two plates, which are by this means made to adhere. But in all the obfervations I have met with, whether made by Prieftley in his Hiftory, or by any other writer, thefe powers have been fuppofed to operate by increafing or diminifhing the diftance between the furfaces. The following facts will fhew that this conclufion requires to be modified.

In the year 1791 I cut a plate of very clear glafs into portions, which were intended to be ufed to defend a veffel of quickfilver from the agitation of the air. Its colour, when viewed edgewife, was a very light green, and it had been carefully ground by an optician, with its fides truly parallel to each other. The thicknefs was twelve hundredths of an inch. A piece 3,2 inches long and 2,4 wide was laid upon another larger piece, both having been previoufly wiped. The refult was, that faint colours appeared in rows about fix or feven in number. Preffure appeared to alter thefe very little in pofition; but it produced other more vivid colours, which were much more moveable, and croffed the former without affecting them. The fcarcely moveable ranges were very little difturbed by the heat of the finger applied againft the undermoft glafs; though this application was fufficient to produce a very great alteration in the figure of the other ranges. When the upper glafs was lightly placed upon the lower, the faint and fcarcely moveable ranges appeared alone, and the glaffes had very little adhefion; fo that the uppermoft flided about on the larger plate beneath, without feeming to carry the ranges with it, but arrived at other ranges, which

which from their immobility seemed as if attached to the lower glass. These scarcely moveable colours, however, were quickly moved, and brought nearer to each other by raising one edge of the glass with the hand; and they continued visible when the glass was lifted as high as one-fortieth or thirtieth of an inch, by slipping a knife under its edge. When a plate of metal was placed beneath the lower glass, and electricity (which from the disposition of the machine happened at that time to be negative) was communicated to the upper plate, the vivid colours appeared, and the adhesion of the glasses was increased; but the scarcely moveable ranges remained little if at all affected. When the glasses were taken from the machine towards the window, the vivid colours slowly receded as the electricity was dispersed, and in this state they were very advantageously and evidently seen crossing the other less moveable ranges.

These facts appeared at that time to lead to no other conclusion than that the moveable ranges had been disturbed by some other circumstance besides that of the mere distance of the plates: for, if the distance had indeed been varied, it seems reasonable to suppose that both sets of ranges would have been affected.

Soon afterwards, upon making some observations with the artificial horizon, and a sextant constructed by Troughton, I observed a series of colours in the horizon-glass, when the position of zero was to be ascertained. They appeared both in the silvered and the clear part. The position of the glasses, when the colours were seen, was very nearly parallel as to the vertical situation of the planes; but it admitted of the index being moved through nearly forty minutes before they disappeared. These glasses, namely the index-glass, and the horizon-glass, were $3\frac{1}{2}$ inches asunder.

This last fact appears to justify the inference of Newton, who considered the colours of thick and thin plates as depending on the same cause; which doctrine was applied by Dr. Pemberton, to account for the numerous ranges of colours sometimes observed beneath the common rainbow *.

As one of the greatest difficulties in Newton's doctrine seems to have been that the fits of reflection and transmission are supposed to extend to vast distances, it seemed desirable to repeat this experiment with as great an interval between the glasses as could conveniently be had. With this view I placed one plate of glass on the surface of a vessel of mercury, and held another in my hand parallel to it, in such a position that the reflected light from the first passed through the second glass to my eye. The white clouded sky and the chimney of an opposite house were seen by reflection in both glasses, and it was easy to move the upper glass till both images of the chimney coincided. In this position the glasses would have been parallel if the object had been indefinitely distant; but in the present case, the parallelism could not be obtained but by a slight elevation of the moveable image. By this disposition the colours were made to appear when the plates were four feet asunder, and I have no doubt but that the same would have happened at much greater distances if the imperfect method of adjusting the parallelism could have been applied.

The same effect, as might naturally be expected, took place when the eye was so placed as to receive the reflected light from the lower glass, after it had been transmitted through the upper.

* Philos. Trans. abridged, vol. vii. or Priestley's Optics, p. 590.

In addition to these observations, it may be remarked, that I have not observed these colours in such plates of common looking-glass as I have tried; that they do not appear in a small pocket sextant which I possess; that the disposition to exhibit these colours seems to be increased by wiping or friction, and also, as I think, by a continuance of the action which is necessary to produce them, or cause them to run along the surface of the glasses.

IX.

Some Account of the Country and Climate of the North-western Lakes of America. By Major C. SWAN, *Paymaster to the Western Army* *.

D'Etroit, Oct. 10, 1797.

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"This country is yet new, and almost in a state of nature, like its inhabitants. It is true the soil is extremely rich and fertile; and it is to a superabundant burden of vegetation, and a flat surface for hundreds of miles together producing much stagnant water, that we may attribute the unwholsomeness of the climate, which is almost certain to affect the inhabitants with bilious complaints every fall †.

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"Gen. Wilkinson arrived here in June this year, and, after making some prompt arrangements for the garrison, proposed a voyage to Michilimackinac, and invited me to accompany him; and on the 4th day of August we embarked in a sloop of about 70 tons burthen. We had a safe and pleasant trip, not only to Michilimackinac, but even into Lake Superior; and returned to this place on the 4th of last month, highly gratified indeed.

"We first left this place, and traversed Lake Sinclair, a handsome circular lake about twenty-five miles across. We then proceeded up the river of that name, which is broad and very handsome, for about forty miles, to a rapid at the entrance of Lake Huron; traversed this immense beautiful lake, three hundred miles long; and arrived on the 15th of August at the streight which unites it to Lake Michigan. This streight is broad; and the Isle de Bois Blanc, or White Wood Island, Round Island, and Michilimackinac Island form a cluster in the middle of the streight, and afford a romantic and majestic landscape from the sea. The Isle de Bois Blanc is eleven miles and a half long, and from two to three wide, lying parallel to the two coasts of the streight, but nearest to the south-side. Round Island

* From the Medical Repository, printed at New York, vol. i. p. 526. It is introduced by the following Note of the American Editor:

Note. The following Article consists of Extracts from a Letter of Major Swan to Capt. Frye, commandant of the garrison at Governor's Island, who was so obliging as to communicate them to one of the Editors; and they are now made public with the consent of the Author. These Extracts are briefly made from a Journal kept by Major Swan at the time; and are inserted for the threefold purpose of illustrating the table of thermometrical observations which follow, of communicating a short but authentic view of a part of the north-western territory, and of inviting further information.

† These remarks have particular reference to the neighbourhood of D'Etroit.

is about three miles in circumference, and lies at the upper or fouth-weft end of De Bois Blanc. The ifland of Michilimackinac is circular, and lies between the upper end of De Bois Blanc and the north-weftern coaft of the ftreight; having a channel of about one mile and a half between it and De Bois Blanc, and a channel of nine miles between it and the north-weftern coaft of the ftreight. It meafures feven miles and three quarters in circumference, and is neatly circular. On the fouth-fide of this ifland there is a fmall bafon of a fegment of a circle, ferving as an excellent harbour for veffels of any burthen, and for canoes. Around this bafon the village is built, having two ftreets of nearly a quarter of a mile in length, a Roman chapel, and containing eighty-nine houfes and ftores; fome of them fpacious and handfome, with white lime plaftering in front, which fhews to great advantage from the fea. At one end, and in the rear of the town, is an elegant government-houfe of immenfe fize, and finifhed in great tafte. It is in the form of ‖⌣‖; one ftory high, the rooms fifteen feet and a half in the clear. It has a fpacious garden in front, laid out with tafte, and extending from the houfe on a gentle declivity to the water's edge. There are two natural limpid fprings in the rear of the houfe, and a very lively grove of fugar-trees called the Park. Suitable out-houfes, ftables and offices are added; and it is enriched on three fides with beautiful diftant profpects. Twenty rods from the rear there is a fudden and almoft perpendicular afcent of about a hundred feet of rock, upon the top of which ftands the fort, built of ftone and lime, with towers, baftions, &c. occupied by our troops, and commanded by Major Burbeck. About half a mile from the fort, in the rear, there is an eminence which I eftimate to be about two hundred and fifty feet from the furface of the water. This fpot commands an extenfive and fublime view of the adjacent country. The fort, the village, the neighbouring iflands and channels feem proftrated at your feet; while to the fouth-weft you look into the immenfity of Lake Michigan, which lofes itfelf in the fouthern hemifphere; and to the north-weft the great Lake Huron lies expanded to the bounds of the horizon. It was a beautiful morning when I had this view.

" This celebrated ftreight is the only key to the immenfe lucrative fkin trade now folely carried on by Britifh fubjects from Montreal, with the nations of Indians, called the Sauteurs or Chipewas, Sioux, Reynards, &c. who inhabit the water-courfes that fall into the Miffiffippi between the Illinois and the falls of St. Anthony. Canoes are loaded and fitted out by thefe traders every year from Michilimackinac. They commonly fet out in July, and return in June, July or Auguft the year following, to Michilimackinac, from whence they ftarted. Here they are again met by the Montreal canoes with frefh goods, exchange loading, and each return from whence they came. The Montreal canoes penetrate to Michilimackinac by way of Grand River; which, with the exception of a fmall portage, conveys them to the northern point of Lake Huron; and return by the fame route. Thofe from Michilimackinac penetrate the interior or Indian country by way of Green Bay, an arm of Lake Michigan, thence through Fox River into the Miffiffippi and its tributary ftreams; and return alfo to Michilimackinac by the fame route.

" On the 22d of Auguft we left Michilimackinac, and on the 23d anchored in the ftreight of St. Jofeph, which leads to Lake Superior. At this place nature has difplayed very handfomely again. The mouth of the ftreight is about thirty miles wide, but fo ftrewed over with innumerable fmall circular iflands that it is difficult to obtain a view in any direction of more than fix or eight miles. Indians have fometimes been loft among

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these islands for weeks together. They extend into Lake Huron, and continue along the north-west coast of the lake for an hundred and eighty miles, and are called by the savages the Meneto or Devil's islands. From the entrance of the streight at a place called the Detour, it is nine miles to the new British garrison built on the point of the island of St. Joseph, commonly called the Carraboo island. This is the largest in the streight; being about twenty-five miles long, and from ten to three broad.

"On the 23d of August we left the vessel, embarked in three canoes, ascended the streight in what is called the Canoe channel, and encamped at Muskito Point.

"The 24th, at one o'clock P. M. we arrived at the falls of St. Marie, called *le Saut de St. Marie.* These falls are about three-quarters of a mile long and half a mile wide; the rapid not violent; and the perpendicular of the whole fall about thirty feet. There is a small kind of village on the United States side containing sundry large warehouses, and a few decent dwelling-houses occupied by the Agents of the Canada North-west Trading Company. There is not a clear white woman in the place.

* * * * "The 25th it rained * * * * * * * * "On the 26th we set off in two bark canoes from the upper end of the portage for Lake Superior. * * *. At one o'clock P. M. we entered Lake Superior; looked fairly into it; drank of its waters; ate our dinner; and put about with a fine fair wind. We reached the falls again at four o'clock in the afternoon; placed experienced guides with strong paddles in the bow and stern of each canoe; hoisted the fifteen stripes; and launched into the bosom of the cataract. In a moment we were safe in the bason at the bottom of the falls!

"We embarked early on the 27th. Having a strong current and fair wind we descended in the ship channel, and reached the vessel at Carraboo island, at nine o'clock in the evening.

"The 28th we put to sea again; and on the 4th of September at sun-down reached this place.

"I inclose to you herewith degrees of heat which were ascertained by regular observation with Fahrenheit's thermometer every day; by which you will perceive that the temperature of the Lakes differs widely from that of the Atlantic country."

On comparing the Table of Observations which is annexed with observations made on the same days in this city, the difference will appear so remarkable that the reader may suspect some error in the instrument made use of by Major Swan: and such were my suspicions. But crossing the East river to Governor's Island in company with that gentleman on the 4th of March 1798, he observed, that the wind which we then felt, and which was very brisk, resembled, in point of temperature, that which he experienced on Lake Huron on the 14th and 15th of August 1797; and added, that on the same evening a frost affected the gardens at Michilimackinac so severely as to destroy the greater part of the vegetables.

TABLE

OF THE

Degrees of Heat obſerved on Fahrenheit's Thermometer, from Auguſt 4, to September 4, 1797.

1797.		6 o'Clock A. M.	12 o'Clock M.	7 o'Clock P. M.	Average.	Remarks, where.
Auguſt	4	66	63½	59	62¼	Lake Sinclair.
	5	59	66	63½	62¼	Ditto.
	6	55½	65	66	62	River Sinclair.
	7	60	67	67	64	Ditto.
	8	59	61	61	60	Ditto.
	9	57	62	52	57	Ditto.
	10	58	62	61	60	Ditto.
	11	63	59½	60	60	Lake Huron.
	12	57	60	61	59	Ditto.
	13	55	55½	55	55	Ditto.
	14	50	49	47	48	Ditto.
	15	45	66	54	55	Michilimackinac.
	16	52	70	53	58	Ditto.
	17	54	69	60	61	Ditto.
	18	52	67	62	60	Ditto.
	19	54	64	56	58	Ditto.
	20	53	64	58	58	Ditto.
	21	62	63	63	62	Ditto.
	22	54	61	59	58	Streights of St. Joſeph.
	23	57	65	60½	62	Ditto.
	24	50	63	60½	57	Ditto.
	25	46	53	49	49	Falls of St. Marie.
	26	46	49	50	48	Lake Superior.
	27	50	56	49	51	Streights of St. Joſeph.
	28	40	50	46	45	Lake Huron.
	29	51	54	51	54	Ditto.
	30	49	57	53	53	Ditto.
	31	50	56	49	51	Ditto.
Sept.	1	48	57	47	50	Ditto.
	2	51	59	50	53	Ditto.
	3	49	58	50	52	River Sinclair.
	4	48	56	49	51	Lake Sinclair.

X.

An Essay on the Art of conveying Secret and Swift Intelligence. By RICHARD LOVELL EDGEWORTH, *Esq. F. R. S. and M. R. I. A.* *.

MODELS of the French Telegraph have been so often exhibited, and the machine itself is so well known, that it is not necessary to describe it minutely in this place. It is sufficient to say, that it consists of a tall pole, with three moveable arms, which may be seen at a considerable distance through telescopes; these arms may be set in as many different positions as are requisite, to express all the letters of the alphabet:—By a successive combination of letters shewn in this manner, words and sentences are formed, and intelligence communicated. No doubt can be made of the utility of this machine, as it has been applied to the most important purposes. It is obviously liable to mistakes, from the number of changes requisite for each word, and from the velocity with which it must be moved to convey intelligence with any tolerable expedition.

The name, however, which is well chosen, has become so familiar, that I shall with a slight alteration adopt it for the apparatus which I am going to describe. *Telegraph* is a proper name for a machine, which describes at a distance. *Telelograph*, or contractedly *Tellograph*, is a proper name for a machine that describes *words* at a distance.

Dr. Hooke, to whom every mechanic philosopher must recur, has written an essay upon the subject of conveying swift intelligence, in which he proposes to use large wooden letters in succession. The siege of Vienna turned his attention to the business. This method is more cumbrous than the French Telegraph, but far less liable to error.

I tried it before I had seen Hooke's work in the year 1767, in London; and I could distinctly read letters illuminated with lamps in Hampstead church-yard, from the house of Mr. Elers in Great Russel Street, Bloomsbury, to whom I refer for the date and circumstance.—To him and to Mr. E. Delaval, F.R.S. to Mr. Perrot of Harehatch, and to Mr. Woulfe the chemist, I refer for the precedency which I claim in this invention. In that year I invented the idea of my present tellograph, proposing to make use of windmill sails, instead of the hands or pointers which I now employ. Mr. Perrot was so good as to accompany me more than once to a hill near his house, to observe with a telescope a windmill at Nettlebed; which places are, I think, sixteen miles asunder. My intention at that time was, to contrive not only a swift but an unsuspected mode of intelligence: By

* Transactions of the R. Irish Academy, vi. 125. The first part of this paper consists of near thirty pages of very interesting historical detail, respecting the art of conveying intelligence by sounds and signals. It was practised by Theseus, in the Argonautic expedition; by Agamemnon, at the siege of Troy; and by Mardonius, in the time of Xerxes. It is frequently mentioned in Thucydides; it was used by Tamerlane; by the Moors in Spain; and by the Welch in Britain; by the Irish; and by the Chinese, on their famous wall of fifteen hundred miles, by which they separated themselves from Tartary. I have omitted this part on account of its length.

means of common windmills this might have been effected, before an account of the French Telegraph was made public *.

My machinery consists of four triangular pointers or hands, each of which points like the hands of a clock to different situations, in the circles which they describe.

It is easy to distinguish whether a hand moving vertically, points perpendicularly downwards or upwards, horizontally to the right or left, or to any of the four intermediate situations.

The eye can easily perceive the eight different positions in which one of the pointers is represented, plate xiii. fig. 1. by turning the eye to the circle A.

A similar circle may be imagined round each of the pointers, by which the numbers which they are intended to express, may be discovered with much facility.

Of these eight positions, seven only are employed to denote figures; the upright position of the hand or pointer being reserved to represent O or Zero. The figures thus denoted, refer to a vocabulary in which all the words are numbered. Of the four pointers, plate I. that which appears to the left hand of the observer, represents thousands, the others hundreds, tens and units in succession, as in common numeration.

† In the annexed plate the four large pointers stand at 2774, which in the common arrangement of my vocabulary, denotes the Royal Irish Academy. For permanent stations, which may be seen clearly with tolerable glasses at twenty miles distance, stone or wooden pillars sixteen or twenty feet high must be solidly erected: on the top of these a moveable circle, or platform, turns horizontally upon a centre: on this platform an axis moves vertically, and carries the arm or pointer along with it. Eight handles turn the pointers,

* Since this paper was written I received a letter from Mr. Perrot, which has been seen by the President, containing the following passage.

" I perfectly recollect having several conversations with you in 1767, on the subject of a speedy and secret " conveyance of intelligence: I recollect our going up the hills, to see how far and how distinctly the arms " (and the position of them) of Nettlebed windmill were to be discovered with ease. As to the experiments " from Highgate to London, by means of lamps, I was not present at the time; but I remember your mention- " ing the circumstance to me, I believe in the same year. All these particulars were brought very strongly to " my memory, when the French a few years ago conveyed intelligence by signals; and I then thought and " declared, that the merit of the invention undoubtedly belonged to you.---I am very glad that I have it in " my power to send you this confirmation, because I imagine there is no other person now living who can wit- " ness your observations in Berkshire."

† I insert, Plate xiii. fig. 2. a line described by telegraphs as an example.—It is the first line of the following verses, written on the prospect of corresponding between England and Ireland by the Telegraph:

Hark from Basaltic rocks and giant walls,
To Britain's shores the glad Hibernia calls;
Her voice no longer waits retarding tides,
The meeting coasts no more the sea divides.
Quick, at the voice of fortune, or of fame,
Kindles from shore to shore the patriot flame;
Hov'ring in air, each kindred genius smiles,
And binds with closer bands the sister isles.

The numbers are, 2645, 2331, 573, 1113, 244, 2411, 6336.

which

which are fixed in their different positions by a catch or alidad. By means of the platform, the pointer may be turned to any part of the compass; and as one side of it is painted black and the other white, either side may be employed, as the colour of the clouds, or the situation of the place, may require.

Besides these permanent machines, of which dimensions and a description are subjoined in plate xiii. I make use of portable machines, (which may be detached like tentacula from the main body in hazy weather,) consisting of pointers ten or twelve feet high, and of a light triangular stand, which can be easily fastened with tent pegs to the ground: these may be lodged in any house near the place where they are used, or in times of danger may be carried back to the permanent stations every night.

In managing a correspondence by these machines, it is necessary to have certain signals established: nor are these signals merely arbitrary; it is absolutely necessary that they should be made by the two external or by the two internal pointers, else they could not be repeated by the intermediate stations without confusion; because, in the middle stations, that pointer which represents thousands when conveying a message eastward for instance, must, when answer is returned in an opposite direction, represent units; the same change will take place between the pointers that denote hundreds and tens.

Certain hours of the day must be appointed for ordinary communication. Suppose ten o'clock in the morning, and five in the afternoon in summer. Every communication begins from the capital. If no intelligence is required to be conveyed from thence, the word BEGIN is sent to the county station, which may then proceed or dismiss the meeting.

When any communication is to be commenced, the pointers that denote thousands and units are whirled round, till the same is done at the corresponding station. When this signal has been answered, the person who gave it proceeds to send his intelligence. As soon as he begins, the pointer of hundreds at the opposite station is turned to two, and kept in that position till the word is made out from the vocabulary; it is then turned up to O or ZERO. The person who is speaking, when he perceives by this signal that he is understood, turns all the machines to NOUGHT, which is always to be done at the conclusion of every word.

When all his machines are in this position, his correspondent again turns his pointer belonging to the place of hundreds to two, where it is to remain till he receives another word, and so on till all that is meant to be said is finished. To denote that his communication is finished *—THOUSANDS and UNITS are to be vibrated backwards and forwards with the point downwards like a pendulum, till the same is done at the opposite station.

If any interruption takes place on either side, from a cloud, a shower, or any accident, it is pointed out by vibrating THOUSANDS and UNITS with their points upwards; which signal must be repeated from the opposite station. Whoever has made the signal of interruption, must make a signal of recommencement, when he is ready to proceed, by vibrating HUNDREDS and TENS, with their points upwards; when this is answered (but not before,)

* I use the words Thousands and Units here, and in the rest of this description, for the pointers or machines that stand in the numerical place of thousands and units.

the

the bufinefs may proceed. It fhould be obferved in general, that every fignal fhould be anfwered.

It requires fome fteadinefs to abide by thefe fignals; but if they are patiently adhered to, the fuccefs that they enfure will foon convince the operator of their utility. Without them every thing would be in confufion; by their interpofition, perfpicuity and order are perfectly enfured.

In my firft experiments the impatience of friends who were prefent, was fometimes fo great as to make it very difficult to adhere to previous arrangements; but a very little practice (I mean the practice of five or fix days) reduced the routine of communication to as much facility as could be defired, fo that a word (or a fentence, if contained in the vocabulary) could be fent in twenty feconds.

Any perfon who has the flighteft tafte for fcience or literature muft be ftruck when he fees inftantaneous interpretation of fignals which are made at the diftance of fifteen or twenty miles, and when he perceives the power which is obtained of tranfmitting thought with fuch aftonifhing rapidity.

I fhall not enter into a detail of the fignals which are neceffary for intermediate ftations; it would take up fome time to explain them, and they will readily occur from what has been faid already.

What I have hitherto defcribed relates to a large and permanent eftablifhment *; for the management of which one man is required at each pointer, one at the telefcope, and another at the vocabulary; but for ordinary purpofes, a fingle pointer, with one man to work it, and another at the telefcope, with a fmaller vocabulary, are fufficient. With this reduced apparatus we can with eafe fpeak at the rate of one word per minute to a great diftance, as the time loft by intermediate ftations is but fmall.

The vocabulary correfponding with the numbers denoted by this machinery, is compofed of a large book with mahogany covers framed, to prevent them from warping. Its fize is forty-feven inches by twenty-one; it confifts of forty-nine double pages, that is to fay, each fheet is folded in the middle, where it opens from one page.

The book is divided into feven parts, confifting each of feven pages, by thin flips of mahogany, which ferve to open it eafily at each of thefe divifions. Every one of thefe feven divifions contains feven pages, and each page contains forty-nine words.

No more than forty-nine words are contained in a page, becaufe the numbers of 8 and 9, and Zero, are omitted. This omiffion arifes from the ftructure of the machinery, which points only to feven numbers, referving O for a point of reft, at which point the hands indicate nothing. In every hundred, therefore, only forty-nine numbers are ufed; and in every thoufand only feven hundred is counted. Each divifion of the book feparated by the mahogany rulers, contains all the efficient numbers in feven hundred. Each of thefe rulers projects (Plate xiii. fig. 3.) beyond the fides of the pages, and each is numbered in fucceffion from one to feven; and they are fo placed below one another, as to permit the numbers on all fides of them to be feen at once, as in plate xiii.

When any number of thoufands is pointed out, it can by means of thefe rulers be im-

* The houfe belonging to this eftablifhment might be made tenable againft a mob, or mufquetry, at a fmall expence, by port flankers of elm or afh adapted occafionally to the windows. See plate xiii. fig. 4.

mediately ſelected; the ſeries of ſeven pages, which one of theſe rulers opens, is cut, like the alphabet of a ledger, at the edge in ſeven diviſions. By theſe means the page containing the hundred which is wanted, is inſtantly found. In the page thus found the tens, from ten to ſeventy incluſive, are divided from each other ſo as to be inſtantly diſtinguiſhable, and the units under each diviſion are in like manner eaſily ſelected.

Plate III. is a ſpecimen of the firſt page of the vocabulary; and though it is but one-fifth of the real ſize, it is ſufficiently diſtinct. It is divided into eight claſſes; all the claſſes are numbered downwards ſeriatim from 1 to 77, omitting cyphers or zero, and eights and nines. When once the claſs required is aſcertained, any number on the page can be found immediately:—As for inſtance, the reader will eaſily ſelect claſs iv. number 36, or claſs vii. number 77, and ſo of the reſt.

Nothing remains to be explained but the manner in which the claſs in each page is pointed out by the machinery. For this purpoſe, before the pointers are turned to any ſet of figures, the pointer that repreſents thouſands is turned to the claſs that is wanted; as ſoon as the correſpondent anſwers this ſignal, THOUSANDS is returned to O, and inſtantly all the pointers are moved to the places which denote the figures required for any word or ſentence.

When the claſs is thus aſcertained, an index, which ſlides on the mahogany cover of the book, is ſet to the column belonging to this claſs; the number of thouſands is then opened by the ruler, as ſoon as it is read off by the teleſcope; the number of hundreds is opened by the pages when they are cut away, and the number of tens and units is ſeen on the page. As the pointers are moved in ſucceſſion from thouſands to units, the different diviſions of the book can be opened as faſt as the pointers are moved. The order of this book might be reverſed with apparent advantage, by dividing the book into claſſes by the mahogany rulers, &c. But I prefer, for reaſons which it would be tedious to inſiſt upon, the arrangement which I have followed.

As ſecreſy is an object of the greateſt conſequence, I ſhall endeavour to point out in a few words the ſuperiority of this mode of communication over any alphabetical arrangement, not only in point of expedition, but of concealment.

Although the common alphabet may be varied at pleaſure, and any arbitrary ſigns may be employed to convey the powers of each letter, yet, by certain rules, any of theſe arrangements may be deciphered. Whoever ſees the movements of the French telegraph (I mean of that which is commonly known as ſuch) may unfold the intelligence which it conveys, by merely marking down the changes which he ſees, and putting them into the hands of a decipherer. The rules for deciphering depend upon the uſual arrangements of letters. In our language a ſingle letter muſt be A or I. The proportions which exiſt between words of one, two, three, and any greater number of letters, are claſſed in catalogues; and from theſe the monoſyllables of any cipher are eaſily obtained, and from the letters of theſe monoſyllables the letters of longer words are diſcovered. By ſimilar rules, ſome of which are very ingenious, and which depend upon the general philoſophy of language, any alphabetical cipher may be eaſily unfolded. But theſe rules, except a very few of them, are uſeleſs, when we employ ciphers which denote entire words. Here the moſt obvious means of diſcovery may be avoided, by omitting thoſe common words which occur ſo frequently in every language, the, and, that, to, &c. But, ſuppoſing that from its frequent recurrence any particular word ſhould be diſcovered, no progreſs can be made from

theſe

these data. The cipher of each word is an isolated fact, which leads to nothing farther. Suppose the knowledge of any particular vocabulary should fall into hands for which it was not intended, a slight change in the numeration, without any actual change of the figures, would entirely prevent discovery:--For instance, if the Lord Lieutenant wished to send orders to the Commander in Chief; if he made use of the numbers written in the vocabulary in one day, he might, after previous communication, employ a different numeration by ordering that 1 (for instance) should be added to every figure. If class ii. number 3664, stood in the vocabulary for gunpowder by the addition which I have proposed, the number would stand class iii. number 4775, which might mean a crocodile, or Tippoo Saib, or any thing foreign to the real word. By similar provisions any number of separate correspondents might carry on a mutual intercourse, without interfering with one another.

In the course of twelve months I tried a great number of experiments, and carried on a great number of conversations with the tellograph; of all these a regular journal has been kept, containing what was unsuccessful, as well as what succeeded. If such journals were kept in the prosecution of philosophical pursuits, they would pay for the trouble of keeping them by the accuracy of the experience which they ensure.

I shall not at present enter into any detail of my Nocturnal Tellograph. Its velocity far exceeds what can be done by day, as in clear weather stations at fifty miles distance may be plainly distinguished.

When this paper was first presented to the Academy, I had determined to try an experiment across the Channel from Donaghadee to Port-Patrick. I was ambitious of being the first person who should connect the islands more closely, by facilitating their mutual intercourse. Public business prevented me from going to the sea-side at the time I had intended, and from carrying on a series of conversations by day and night between the two kingdoms; but Mr. Lovell Edgeworth, my son, had the satisfaction of sending four messages across the Channel at four o'clock P. M. on the 24th of August 1795, and of receiving immediate answers before a vast concourse of people. The machines by which this communication was made, were thirty feet high, and fifteen feet at the base. A child of four years old could turn them. Misty weather prevented them from being seen; but when the weather cleared up, a pointer of twelve feet high could have been plainly distinguished across the Channel.

Though I have bestowed much attention and labour upon this subject, I do not pretend to say that the means of tellographic communication, which I have invented, are the best that can be devised. Imitations without end may be attempted; pointers of various shapes and materials may be employed; real improvements will also probably be made; and, perhaps, new principles may be adopted. The varieties of art are infinite, and none but persons of narrow understanding, who feel a want of resources in their own invention, are jealous of competition and disposed to monopolize discoveries. The thing itself must sooner or later prevail, for utility convinces and governs mankind; and however inattention or timidity may for a time impede its progress, I will venture to predict, that it will at some future period be generally practised not only in these islands, but that it will in time become a means of communication between the most distant parts of the world, wherever arts and sciences have civilized mankind.

TABLE.

SPECIMEN OF THE VOCABULARY
BELONGING TO
MR. EDGEWORTH's TELLOGRAPH.

Common Words. Claſs 0.	Words leſs common. Claſs 1.	Technical Terms, c. n. m. Claſs 2.	Perſons. Claſs 3.
1.	1.	1.	1.
11 A	11 Abaſe	11 Aback	11 Abbot
12 Ab	12 Abate	12 Abacus	12 Ackland
13 Ac	13 Abbey	13 Abaft	13 Acton
14 Ad	14 Abbeſs	14 Abatis	14 Acheſon
15 Ae	15 Abbot	15 Abdomen	15 Adams
16 Af	16 Abdicate	16 Abductor	16 Adamſon
17 Ag	17 Abed, Abet	17 Abeal	17 Adair
2.	2.	2.	2.
21 Ah	21 Abide	21 Aberration	21 Adolphus
22 Ai	22 Abjure	22 Abeyance	22 Addington
23 Ak	23 Ablative	23 Ablution	23 Ahmuty
24 Al	24 Able-bodied	24 Abortion	24 Aikin
25 Am	25 Aboliſh	25 Abreaſt	25 Alcock
26 An	26 Abomination	26 Abrogation	26 Aldridge
27 Ap	27 Abortive	27 Abſceſs	27 Allot
3.	3.	3.	3.
31 Aq	31 Above-all	31 Abſcis	31 Alley
32 Ar	32 Above-board	32 Abſcenthium	32 Allett
33 As	33 Above-mentioned	33 Abſorbent	33 Allen
34 At	34 Abridge	34 Abſorption	34 Alder
35 Av	35 Abridgement	35 Abſtergent	35 Alexander
36 Au	36 Abruptly	36 Acacia	36 Amyatt
37 Aw	37 Abſentee	37 Academic	37 Ambroſe
4.	4.	4.	4.
41 Ay	41 Abſolve	41 Acantha	41 Anderſon
42 Ax	42 Abſolution	42 Accretion	42 Andre
43 Az	43 Abſorb	43 Aceſcent	43 Andrews
44 Abandon	44 Abſtract	44 Acetous	44 Angel
45 Abuſe	45 Abſtruſe	45 Achromatic	45 Anger
46 Abhor	46 Abſurdly	46 Acids	46 Anneſly
47 Abject	47 Abyſs	47 Acidity	47 Anneſdale
5.	5.	5.	5.
51 Ability	51 Academy	51 Acme	51 Antrim
52 Able	52 Accelerate	52 Aconite	52 Anſon
53 Above	53 Accent	53 Acouſtics	53 Anſtruther
54 Abound	54 Acceſs	54 Acroſtic	54 Antonie
55 About	55 Acceſſary	55 Adamant	55 Anthony
56 Abundance	56 Acceſſible	56 Adder	56 Alfred
57 Abroad	57 Acclamation	57 Adder's-tongue	57 Alphonſus
6.	6.	6.	6.
61 Abrupt	61 Accommodate	61 Adductor	61 Amadeus
62 Abſent	62 Accomplice	62 Adelphi	62 Anne
63 Abſence	63 Accoſt	63 Ades	63 Anſolm
64 Abſolute	64 Accountant	64 Adit	64 Appleby
65 Abſtain	65 Account-book	65 Adjutant	65 Apſley
66 Abſurd	66 Accretion	66 Adnata	66 Archer
67 Abſtain	67 Accrue	67 Adonis	67 Auſtin
7.	7.	7.	7.
71 Abuſe	71 Accumulate	71 Adoſculation	71 Archdale
72 Accede	72 Accuſative	72 Adracanth	72 Arran, Ld.
73 Accept	73 Ace	73 Adrift	73 Archdall
74 Acceptable	74 Achieve	74 Advance-foſſe	74 Aſhe
75 Accident	75 Acquiſition	75 Advance-guard	75 Atkinſon
76 Accompany	76 Acquittance	76 Advancement	76 Aylward
77 Accompliſh	77 Acre	77 Advertiſement	77 Ayre

Officers. Class 4.	Places. Class 5.	Navy and Merchant Ships. Class 6.	Phrases and Sentences. Class 7.
1.	1.	1.	1.
11 Academy of Inscriptions	11 Abbeville	11 Atlas	11 Attend to-day at A. M.
12 Academy of B. L. Paris	12 Aberdeen	12 Ajax	12 ———— at P. M.
13 Academy	13 Abergavenny	13 Albion	13 —— to-morrow at A. M.
14 Account Office	14 Abington	14 Africa	14 ———— at P. M.
15 Admiralty	15 Abydos	15 Audacious	15 —— to-night at ——
16 Agent to the —	16 Abyssinia	16 Agamemnon	16 —— to-morrow night at —
17 Admiral	17 Acadia	17 America	17 —— on Monday at A. M.
2.	2.	2.	2.
21 Adjutant	21 Acaniboo	21 Anson	21 ———— at P. M.
22 Alderman of Bristol	22 Acapulca	22 Alcide	22 —— on Tuesday at A. M.
23 Alderman of Cork	23 Acam	23 Alexander	23 ———— at P. M.
24 Alderman of ——	24 Adda	24 Alfred	24 —— on Wednesday at A. M.
25 Archdeacon of —	25 Adrianople	25 Arrogant	25 ———— at P. M.
26 — Ardagh —	26 Ætna	26 Asia	26 —— on Thursday at A. M.
27 — Ardfert —	27 Africa	27 Ardent	27 ———— at P. M.
3.	3.	3.	3.
31 — Armagh	31 Agincourt	31 Achilles	31 —— on Friday at A. M.
32 — Acowry	32 Aix la Chapelle	32 Adamant	32 ———— at P. M.
33 — Aghadoe	33 Albany	33 Assistance	33 —— on Saturday at A. M.
34 — Clogher	34 Alcantara	34 Acteon	34 ———— at P. M.
35 — Clonfert	35 Aleppo	35 Argo	35 Alarming Intelligence is received from —
36 — Cloyne	36 Alexandria	36 Artois	
37 — Connor	37 Algiers	37 Assurance	37 Acquaint the Commissioner's Officers at —
4.	4.	4.	4.
41 — Dublin	41 Alicant	41 Arethusa	41 — principal Magistrates at —
42 Archbishop of —	42 Alps	42 Æolus	42 — the High Sheriff at —
43 — Dublin	43 Alsace	43 Active	43 — the Secretary of War
44 — Armagh	44 Antrim	44 Alarm	44 ———— of State
45 — Cashel	45 Aylesbury	45 Amazon	45 Agreeable to the Orders of his Majesty
46 — Cork	46 Ayrshire	46 Ambuscade	
47 — Canterbury	47 All Saints	47 Amphion	47 — of the Lord Lieutenant
5.	5.	5	5.
51 — Tuam	51 Alnwick	51 Apollo	51 — of Government
52 — York	52 Aloft	52 Astrea	52 — of the Commanding Officer at —
53 Admiral of	53 Alresford	53 Alcmene	53 — of the Magistrate of —
54 — the Fleet	54 Aldborough	54 Andromache	54 Agreeable to your Orders
55 — the White	55 Alençon	55 Albemarle	55 All is well
56 — ditto 1	56 Andes	56 Aurora	56 Alter your Telegraphs to Black
57 — ditto 2	57 Anglesey	57 Amphitrite	57 ———— to White
6.	6.	6.	6.
61 — ditto 3	61 Angola	61 Ariadne	61 Admit no Strangers
62 — ditto 4	62 Anjou	62 Alfred	62 Admiralty has issued Orders
63 — ditto 5	63 Anhalt	63 Atalanta	63 — has received Intelligence
64 — ditto 6	64 Antioch	64 Ariel	64 Arms been found hidden at —
65 — ditto 7	65 Antwerp	65 Allegiance	65 Army approaches in Number
66 — ditto 8	66 Archangel	66 Albany	66 An armed Mob at —
67 — ditto 9	67 Argenton	67 Alderney	67 Art. of Capitulation agreed to
7.	7.	7.	7.
71 — ditto 10	71 Atherstone	71 Alert	71 Assistance is required at —
72 — ditto 11	72 Ardee	72 Alligator	72 Appearances are against —
73 Admiral of	73 Arklow	73 Avenger	73 Answer my last to-morrow
74 — the Blue	74 Armagh	74 Ætna	74 Arrived since my last at —
75 — ditto 1	75 Athenry	75 Alecto	75 Arrived News from E. Indies
76 — ditto 2	76 Athlow	76 Aquillone	76 Arrived Mails from —
77 — ditto 3	77 Athy	77 Argus	77 Agreeable Intelligence is received

SUPPLEMENT.

SINCE the Royal Irish Academy did me the honour to accept of my essay on the Telegraph, I have made material improvements in its construction, which I think it my duty to communicate.

In September 1796, the Lord Lieutenant ordered me to prepare Telegraphs for an experiment before his Excellency. In consequence I constructed four new Telegraphs.—I had found that the large machines thirty feet high, with which my sons talked, in September 1794, across the channel between Ireland and Scotland, were liable to accidents in stormy weather: my first consideration therefore was to contrive some means of furling their canvas when they were not in in use; and, from the rigging of ships, it was obvious that cordage was for this purpose preferable to inflexible braces of wood. I therefore adopted the following construction:

A. (fig. 4. Plate XIV.) a hollow axle-tree made in separate pieces hooped together in the form of a double truncated cone, on the middle of which is fastened a wheel of wood (b, fig. 4) with eight notches cut out (a, fig. 4) to receive eight ribs (r. r. r. r. r. r. r. r fig. 1 and 2.) These ribs turning on a strong iron ring, shut up like the ribs of an umbrella, and are raised and adjusted by cords passing through eight holes in the flanches or shoulders (F fig. 1. 4.) These flanches and those at (f. fig. 2 and 4) serve to keep the machine in its place upon the stands which support it (fig. 2); the cords are strained and fastened like the cords of a tent (c. c. &c. fig. 2.)

Where permanent buildings are not required, supports for these machines may be constructed in the following manner. Two stands, each of them made of two pieces of wood simply bolted together, as (fig. 3), must be erected, and held steady by means of cords (c. c.) fastened to common tent pegs, as in (fig. 2 P. P. P.) When the machines are large, small piles should be used instead of pegs, and running tackle (t.) should be used both for the cords of the pointers, and the stands. A number of minute circumstances should be attended to in the construction and use of these machines; but I do not think it proper to detail them to this Academy; they should appear in a different place *.

Besides rendering the Telegraph safe against storms, and more easily manageable, I found by experience that one machine could be made to perform the same effect as four, with but little loss of time; what took up four minutes with four pointers, can be conveyed in five minutes by one. I have also found that, by answering each signal or number shown at every station, all possibility of mistake is avoided.

I believe that, in other establishments of this sort, it has been found that thick and foggy weather has occasioned more interruptions than were expected. With my Telegraphs, I

* Formerly, in France, every engineer who conducted any public work, was obliged to lodge in a public office exact drawings, with minute descriptions, of every part of and process of his operations. Numberless small improvements in workmanship and tools were preserved by these means, and by degrees were collected into publications of general circulation.

I was required to deliver drawings of all the machinery I employed in the work carried on at Lyons in 1772, for turning the course of the Rhone:

But, in the transactions of a literary Society, such details would be tedious and improper.

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have good reason to assert, that there do not commonly occur above eight or ten days in the year when intelligence might not be conveyed by land.

If eight men were posted at each permanent station, at the distance of eighteen or twenty English miles asunder, with machines of twenty-five feet high, in hazy weather they might detach two men with portable Telegraphs, to the distance of about six miles from each station, who, with eight foot Telegraphs, could keep up a regular communication.

The portable Telegraph resembles that which I have described; it differs only in two circumstances: for convenience, as it is small, and does not oppose much surface to the wind, it may be distended with ribs of wood instead of cords.

The portable Telegraph which my son had the honour of showing to his Royal Highness the Duke of York in Kensington gardens, in October last, was furnished with silken cords, on purpose to shew how my larger Telegraphs were constructed; but it was intended merely for reconnoitring near an army, and was only six feet high.

In the essay which the Academy has already received, I said that imitations without end might be made of my Telegraph. Every index or pointer that moves circularly, dividing an imaginary circle into parts, and denoting figures or signs that correspond with a vocabulary, is founded on the same principle as mine. The French have laid aside their former clumsy apparatus, and have constructed a Telegraph on these principles; and the Admiralty in England have, as I am informed, very lately done the same.

The first pointers I employed in 1767 were windmill sails. I then tried indexes of the shape (fig. 5.) Fig. 8. A pointer, like a sword-cutler's sign, was recommended to me by a member of the Academy, as a second or additional hand to move on the same centre as the principal hand. But a triangle, whose base is equal to half its side, is, of all the figures I have tried, the most distinct.

The Night Telegraph remains still to be described; its uses are perhaps more extensive than those of the Telegraphs I have already published; and I propose to make it the subject of another paper upon a future occasion.

The art of conveying swift and secret intelligence is not one of those inventions which attracts attention only by its novelty; on the contrary, I am convinced that it will be thought more valuable, the longer it has been submitted to the test of time and experience.

SCIENTIFIC NEWS, AND ACCOUNT OF BOOKS.

COPENHAGEN, *July* 12, 1798.

THE Royal Society has proposed the following Prize Questions. The Prize for each is a Gold Medal, value one hundred rixdollars (22l. 10s.)

I. *History*. What nations discovered America before the Norwegians, and performed voyages by sea to this part of the globe? How far did the Norwegians extend their discoveries in America, particularly to the southward? What conclusions may be deduced on these points, either from decisive reasons or simple conjectures, from the writings and monuments which still subsist, such as forts, buildings, languages and traditions?

II. *Mathematics*. To find the function of all the quantities, which serve conjointly to determine the magnitude of the calorific effect of every combustible material in common use;

use; such as wood, turf, and pitcoal, whatever may be their peculiar characters in other respects. The required equation must be determined for at least four different cases:

Case 1. Where the wood, turf, or coal is burned in a furnace to heat a certain volume of air, as for example, that of a chamber.

Case 2. Where the heat is employed in producing the state of ebullition, in a fluid proper to boil certain substances plunged in it.

Case 3. Where the heat is employed to harden soft matters, such as clay for tiles.

Case 4. And where certain hard or consistant matters, such as metals, are required to be liquified by heat in a furnace or forge. Each of these equations grounded on various experiments must be found and established analytically, so that it may be possible to determine with precision the ratio of the calorific effect, and consequently the degree of utility in economical applications of every kind of wood, turf, or pitcoal.

III. *Natural Philosophy.*—To find by experiment the greatest degree of heat which water in the state of vapour can communicate to other bodies; and to answer the question, whether that part of the water in Papin's digester, which is not converted into steam, can acquire a more elevated temperature than 212° of Fahrenheit.

IV. *Philosophy.*—What are the most remarkable degrees, through which practical philosophy has passed from the time in which it was first treated systematically to the present time.

The memoirs in answer to these questions are required to be written in Latin, Danish, or German, and sent before the end of June 1799, to the Secretary of the Society, Professor Abilgaard.

BERLIN,

The Physical Society at Berlin has announced the following Question, for a Prize of 20 Holland Ducats. (9l. 5s.)

ADMITTING that Electricity is a necessary Agent for the formation of Hail, are there any grounds for concluding, that the Electrical Cloud can be rendered incapable of generating Hail, as Lightning is prevented by Conductors? What are the means to be adopted for this purpose, and the facts or observations in general upon the subject which deserve notice?

Proceedings of the Association for promoting the Discovery in the interior Parts of Africa, &c.

Abstract of Mr. Park's Travels. [Continued from page 283.]

INFORMATION of a considerable river flowing through the centre of Africa, between the latitude of 15° and 20° north, had been received at very early periods from different quarters, which at different times was supposed to be part of the Senegal and of the Gambia. Further enquiries, however, though they confirm the ancient accounts, shewed that this river was not only of greater magnitude than either the Senegal or Gambia, but flowed in a contrary direction, running not to the westward into the Atlantic, but from west to east, to regions unknown. The Moors described it by the name of Nil il Abeed, or the River of Slaves: the Negroes bestowed upon it the appellation of Joliba, or the Great Waters. Something, however, of doubt still remained, particularly with regard to its

eastern

eastern direction, which was not received by geographers without difficulty and hesitation. Mr. Park's testimony is decisive, not only that the two names denote the same stream, but also that it flows from west to east, which he ascertained by a perilous ambulation of some hundred miles along its bank. All question respecting the source, the existence, and the direction of this great river is therefore obviated, but its termination still remains unknown.

The city of Sego, at which Mr. Park now arrived, consists of four divisions or quarters, two on each side of the water. The houses are built of clay with flat roofs: some of them have two stories, and many are white-washed. Moorish Mosques are seen in every quarter. These objects, with the numerous boats on the river, a crowded population, and the cultivated state of the surrounding country, formed altogether a prospect of civilization and magnificence, which our traveller little expected to find in the bosom of Africa. From the best enquiries he could make, he had reason to believe that Sego contained thirty thousand inhabitants.

The boats on the Niger are of a singular construction, each being formed of the trunk of two large trees, hollowed out and joined together endways, the junction being exactly across the middle of the boat. They are, therefore, very long and narrow, and have neither decks nor masts. Mr. Park proceeded to the ferry, in order to cross to the King's residence, which was on the other side; but before he could obtain a passage, the King had sent to enquire concerning the object of his journey. Mr. Park gave the best answer he could, adding, that he had been robbed of all he possessed, and implored the King's bounty and protection. The messenger told him to go to a distant village, which he pointed out, and wait for the King's further orders. He found the inhabitants either afraid or unwilling to give him lodging or entertainment, and having turned his horse loose, he sought shelter from a storm of thunder and rain under a tree. At length as night approached, that kindness and humanity inherent in the female sex, to which he had often been indebted on former occasions, came to his relief on the present. A poor Negro woman returning from the labours of the field, observed that he was wet, weary, and dejected; and taking up his saddle and bridle told him to follow her. She led him to her cottage, lighted up a lamp, procured him an excellent supper of fish, and plenty of corn for his horse; after which, she spread a mat upon the floor, and said he might remain there for the night. For this well-timed bounty our traveller presented her with two of the four brass buttons which remained on his waistcoat.

Mr. Park adds other particulars concerning his benefactress, which heighten the picture. He relates, that the good woman having performed the rites of hospitality towards himself, called in the female part of the family, and made them spin cotton for a great part of the night. They lightened their labours by songs: one of which must have been composed extempore, for our traveller was himself the subject of it; and the air was, in his opinion, the sweetest and most plaintive he ever heard. The words, as may be expected, were simple; and may be literally translated as follows: "The winds roared, and the rain fell. The poor white "man faint and weary, came and sat under our tree. He has no mother to bring him milk, "no wife to grind his corn."—Chorus—"Let us pity the white man, no mother has he, "&c. &c." Simple as these words are, they are natural and affecting; and contain a curious allusion to the state of manners in savage life, in which the women perform all the domestic duties.

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He continued all the next day in the village without receiving any orders from the king, and found himfelf the object of univerfal obfervation and enquiry. He foon heard enough to convince him that the fufpicions of the Moors and flave-traders refiding in Sego were very inimical to him; and that many confultations had been held with the king concerning his reception and difpofal. On the third day however the meffenger arrived with a prefent of five thoufand kowries, to enable him to purchafe provifions in his journey from Sego, from the vicinage of which he was commanded to depart immediately. From various circumftances, it feemed probable that the king would have admitted Mr. Park into his prefence, if he could have protected him againft the malice and fanaticifm of the Moors, and if the ftory of Mr. Park had been more comprehenfible by men, who could not conceive how the defire of extending knowledge could have induced him to travel through fuch an extent of country, without other views of a more objectionable nature. From other enquiries it was alfo rendered certain, that our traveller would have expofed himfelf to certain deftruction from the Moors, if he had ventured to proceed much further to the weftward without the protection of fome leading man among them, which he had no means of procuring. Notwithftanding thefe difcouraging circumftances, he determined to endeavour to penetrate further along the banks of the Niger. The firft town of note at which he arrived after leaving Sego, was called Kabba. This town is fituated in the midft of a beautiful and highly cultivated country, bearing a greater refemblance to the centre of England than Mr. Park could have fuppofed to have been in the middle of Africa, and the feafon was that of the fhea harveft, or gathering in the fruit which produces the fhea-toulou or tree-butter, the great abundance of which in this quarter was aftonifhing. The growth and preparation of this commodity feem to be among the firft objects of African induftry, in this and the neighbouring ftates, and it conftitutes a main article of their inland commerce. From Kabba, Mr. Park and his guide proceeded to Sanfanding, where notwithftanding his endeavours to avoid the notice of the Moors, he underwent their infults for a confiderable time.

Leaving this place early in the morning, he proceeded to a town called Nyara, and thence to Modiboo, a delightful place on the banks of the river, which is here very broad and enlivened with many fmall and verdant iflands, all of them ftocked with cattle, and crowded with villages. Here he was again compelled to fet off abruptly for fear of the Moors. The limit of his expedition to the weftward was Silla, a large town on the fouthern fide of the Niger, in 1° 24′ Weft of Greenwich, and latitude 14° 48′ North, where, from the aggregate of unfavourable circumftances, it became abfolutely neceffary for him to return.

The town of Silla, whence Mr. Park began his journey homeward, is within two fhort days journey of Jenné, which is fituated on an ifland in the river. At the diftance of two days more, the river empties itfelf into a confiderable lake called Dibbie, (or the dark lake) concerning the extent of which, all the information which could be obtained was, that, in croffing it from weft to eaft, the canoes lofe fight of land one whole day. From this lake the water iffues in many different ftreams, which terminate in two large branches, one whereof flows towards the north-eaft, the other to the eaft; but they join again at Kabra, one day's journey to the fouthward of Tombuctoo, and the port, or fhipping place, of that city. The tract of land which the two ftreams encircle, is called Jinbala, and is inhabited by negroes; and the whole diftance by land from Jenné to Tombuctoo, is twelve days journey.

From Kabra, at the diftance of eleven days journey down the ftream, the river paffes to the

the ſouthward of Houſſa, which is two days journey diſtant from the river; and ſo far our information ſeems to be authentic. Of the further progreſs of this great river and its final exit—whether it be the ſame which paſſes by Kaſſina*—whether (as ancient charts ſeem to indicate) it ſpreads into one or more inland lakes; or, at an immenſe diſtance, intermixes with the waters of the Egyptian Nile—theſe are queſtions which future diſcovery can alone reſolve. On each of theſe points enquiry of the natives was not neglected, but ſatisfactory and certain information could not be obtained.

Such is the intelligence that was collected by Mr. Park concerning the courſe of the Niger from its leaving Sego, where he firſt diſcovered it. Of the chief towns of Jenné, Tombuctoo, and Houſſa, ſituated on its banks, the laſt was ſaid to be the moſt conſiderable, and the leaſt of them of far greater magnitude than Sego. But there is a place between Jenné and Tombuctoo deſerving notice, as containing a very conſiderable pottery: it is called Downie; and the earthen ware, which Mr. Park frequently met with, appeared to be of extraordinary good conſiſtency, but not glazed. He was told that caravans frequently arrive both at Tombuctoo and Houſſa, from the countries on the Mediterranean, travelling acroſs the Deſert, by the way of Fezzan, with European goods and other merchandize. By one of theſe the news was conveyed to the centre of Africa of the capture, by the French, of the Mediterranean convoy, in October 1795. Mr. Park received this information from a Moor who had come from Fezzan.

On his return back, Mr. Park learned that the ſovereign of the country had given orders to ſeize him, for which reaſon he avoided the town of Sego. His courſe, in aſcending the river, was to the ſouth-weſt; and his ſubſiſtence, in travelling through the territories of the benevolent Negroes, was in a great meaſure afforded him by the Dooty, or chief man of the towns through which he paſſed, it being, highly to the credit of the African police, part of the duty of this officer to provide food for the neceſſitous traveller. On many occaſions he offered to pay for what he received out of the kowries, which had been preſented him by the king, and his offer was ſometimes accepted and ſometimes refuſed. On other occaſions he rewarded his hoſt in a manner which, from its ſingularity, deſerves to be noticed. Among the various impoſtures practiſed by the Moors towards the poor Negroes, they frequently ſell them ſcraps of paper with an Arabic inſcription (commonly a paſſage from the Koran) which are called *ſaphies* or charms. With one of theſe about his perſon, the fond poſſeſſor conceives himſelf invulnerable: neither the lurking ſerpent nor the prowling tiger is any longer the object of his dread.

In the circumſtances to which Mr. Park was reduced, he had the good fortune to diſcover that the negro natives aſcribed to him the power of granting ſaphies of more than Arabic virtue. "If a Moor's ſaphie is good (ſays the Dooty of Sanſanding), a white man's muſt needs be better;" and Park, at his requeſt, gave him one poſſeſſed of all the virtues he could concentrate, for it contained the Lord's Prayer. The pen with which it was written, was made of reed; a little charcoal and gum-water made very tolerable ink, and a thin board anſwered the purpoſe of paper. In his journey weſtward, this merchandize turned to extraordinary good account; and it is ſurely needleſs (ſays Mr. Edwards) for Mr. Park to frame any apology for having availed himſelf of ſuch a reſource in his ſituation.

* Erroneouſly ſpelt in the former memoirs, Caſhna.

[*To be continued.*]